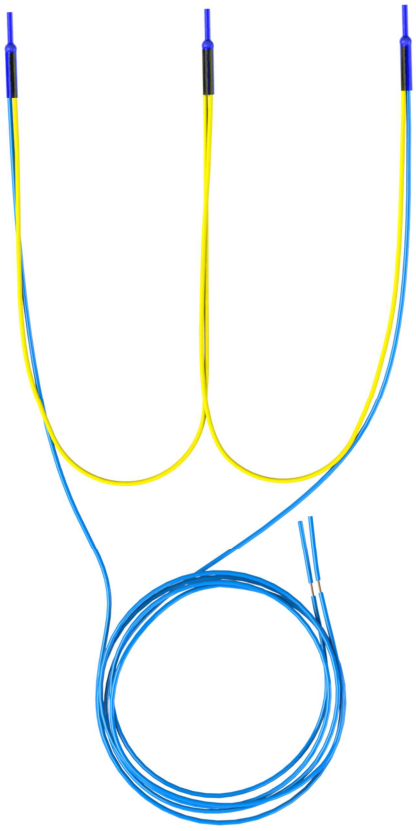
Product Information

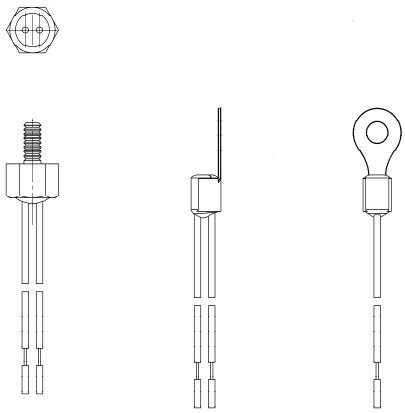
Motor and machine protection

Temperature monitoring with PTC-thermistors

PTC-thermistor
for windings control



PTC-screw-in-sensor and surface sensor



- Basic information

PTC thermistors are ceramic semi-conductors which because of the very high Positive Temperature Coefficient lend themselves to a variety of applications.

- Applications

Specially constructed versions of these products are available and this facility enables most applications to be catered for. Most typical application for PTC thermistors is to protect the windings of heavy duty motors and transformers.

- General function

The PTC thermistor, for the thermal protection of electrical machines, is a temperature dependent component. The rated operating temperature (ROT) corresponds to the curie point temperature of the ceramic. The resistance, of the PTC thermistor, rises very steeply with relatively small increases in temperature, thus triggering the switching function.

- Advantages

- Precise repeatability of the response point.
- Long hysteresis free switch cycle life.
- Extremely cost effective.
- Steep temperature-resistance curve characteristic allows for simple evaluation electronics.
- Current self-limiting.
- Light weight.
- Low thermal time constant.
- Extremely small designs are available.

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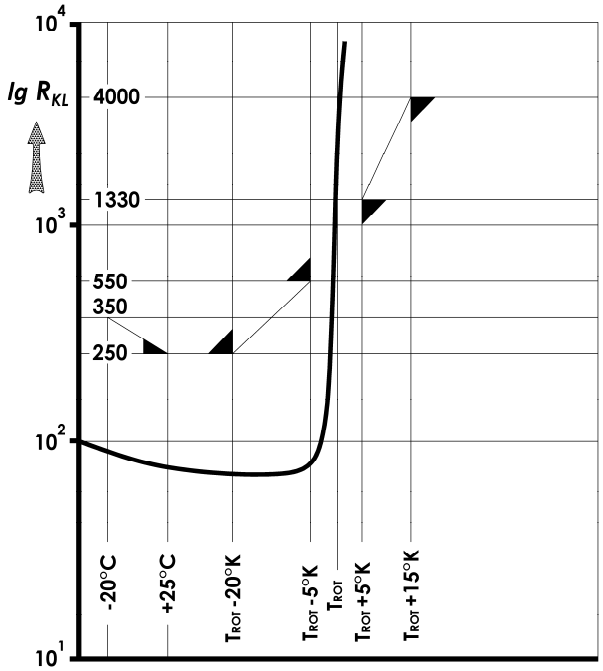

Typical resistance and characteristics of single PTC-thermistors

$R_{KL} = f(T_{KL})$

- Technical base data

Typical resistance-temperature characteristic

The advantage of PTC-thermistors is demonstrated by the very steep curve as shown in the graph. This graph shows the relationship between temperature and resistance. The characteristic of the curve demonstrates the accuracy of the PTC's. The increase in the resistance from the switching point onwards is exponential. The DIN-standards relevant to these products cover the temperature range from +60°C to +180°C and are DIN 44081 and 44082.

Resistance values (according to DIN 44081 and DIN 44082)

The resistance temperature characteristic of PTC-thermistors for the thermic protection of machines is defined by the following formula:

Temperature Range (T_{KL})	PTC-Resistance (R_{KL})	Measuring DC voltage U (test voltage)
-20°C to T_{ROT} -20K	$R_{KL} \leq 250\ \Omega$	$U \leq 2{,}5$ V
at T_{ROT} -5K	$R_{KL} \leq 550\ \Omega$	$U \leq 2{,}5$ V
at T_{ROT} +5K	$R_{KL} \geq 1330\ \Omega$	$U \leq 2{,}5$ V
at T_{ROT} +15K	$R_{KL} \geq 4000\ \Omega$	$U \leq 7{,}5$ V

Load must not be applied to the thermistors as this creates a self-heating effect.

At ambient temperature the resistance value of thermistors is normally between 50 Ω and 100 Ω. It can also be between 30 and 250 Ω. At ambient temperature the resistance values have no relevance to the serviceability (functionality) at the ROT (rated operating temperature).

The ROT of PTC-thermistors in the range of +60°C to +180°C progresses normally in steps of 10 K.

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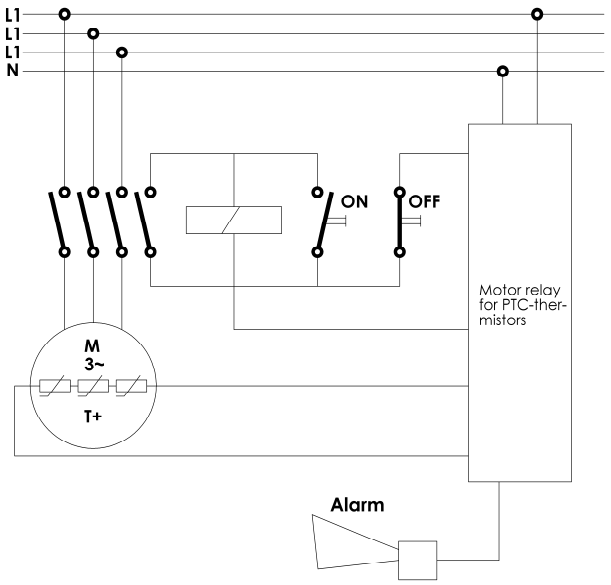

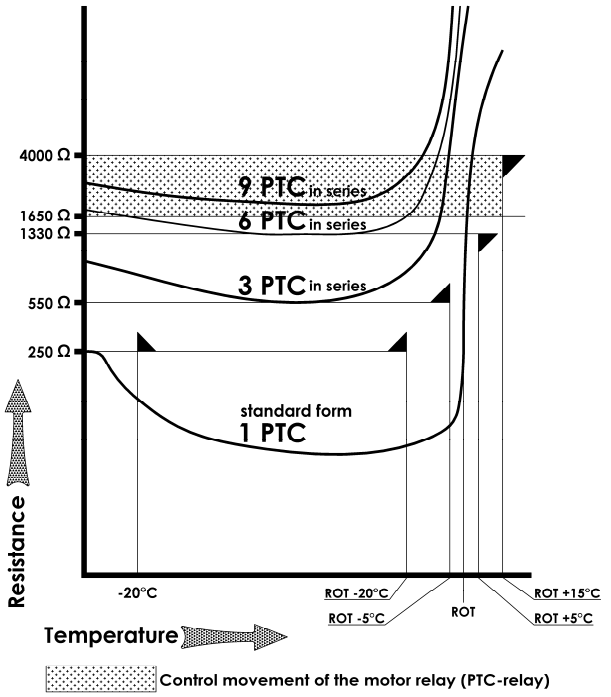

Application-example for electric motor- and machine protection

The accurate sensitivity and small dimensions of PTC's makes them ideal for all electrical machine protection applications. For electric motor or transformer protection the PTC must be placed within the windings. The ROT (rated operating temperature) is chosen in relation to the insulation class of the windings. Three-phase motors will require 3 PTC-Thermistors, wired in series. The terminal leads of the PTC must be connected through a terminal block to a relay and cut-off device (Schütz). When the temperature of the motor exceeds ROT the relay is activated and triggers the power cut-off. When the temperature of the windings cools to below ROT the low resistance of the PTC-thermistor will allow the motor (transformer) to be re-started.

Control-relays suitable for use in conjunction with PTC's are produced by several manufacturers including SIEMENS 3UN6, SEVA-tec TMS 100 and TMS 200. But also all other standard control-relays can be used.

PTC-operational range for use with control relays for temperature protection

Control relays trip normally between 1650Ω and 4000Ω (according to DIN VDE 0660).

Switching points for 1, 3, 6 und 9 PTC-thermistors connected in series is shown in the diagram:

- 1 PTC switches no later than T_{ROT} +15 K, no earlier than T_{ROT} +5 K.
- 3 PTC switch no later than T_{ROT} +5 K, no earlier than T_{ROT} -5 K.
- 6 PTC switch no later than T_{ROT}, no earlier than T_{ROT} -20 K.
- 9 PTC at ambient temperature have a combined resistance value which is automatically within the switching boundaries of the control-relay.

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Motor and machine protection

Temperature monitoring with PTC-thermistors

Mechanical and electrical qualities

characteristics	standard form K155, KZ 255, KD 355,G 155, GO 155	miniature form K135, KZ 235, KD 335,G 135, GO 135
pellet diameter	approx. 3-3,5 mm	approx. 2-2,5 mm
shrink tube	Kynar, ca. 15mm	Kynar, ca. 11mm
leads	stranded silvered copper wire insulated with Teflon (PTFE), AWG 24, or AWG 26 according to the manufactures choice.	
length single-sensor: twin-sensor: triple-sensor:	 500 ± 10 mm 500/180/500 ± 10 mm 500/180-180/500 ± 10 mm	
colour code	colour coding is to DIN 44081 and 44082 see table on page 6	
endconnections	half plucked	
insulation strength	U ≥ 600 VAC	
lead resistance	at +20°C: AWG26= 133 Ω/km; AWG24= 82,7 Ω/km	
admissable working temperature	up to +200°C	
maximum working voltage model Siemens: model Philips:	 U_{max} = 30V DC U_{max} = 25V DC	
DC measuring voltage	U = 2,5V DC	
testing of insulation: wire against insulation (insulation strength)	U_{eff} = 2500V AC	
rated operating temperature T_{ROT} in 10K steps: in 5K steps:	 +60°C to +180°C +145°C, +155°C	
Tolerance Δ T_{ROT} ROT=+60°C to +160°C: ROT=+170°C to +180°C:	 ± 5 K ± 6 K	 ± 5 K ± 7 K
operational cut-off time	< 5 s	< 3 s
Climatic categories as stated in DIN 40040	HFF: lower category temperature: H = -25°C upper category temperature: F = +180°C humidity class F: average relative humidity = 75%, 95% continuously on 30 days per year, 85% occasionally on the remaining days, dew precipitation inadmissible	
storage temperature	minimum: -25°C maximum: +65°C	

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insulation class

The insulation class of machines suitable for protection with PTC's is graded according to VDE 0530 and this is demonstrated in the table below.

Insulating material class	Y	A	E	B	F	H	C
classified temperature limit	+90°C	+105°C	+120°C	+130°C	+155°C	+180°C	over +180°C

insulation test

Before testing the leads of the sensors have to be connected electroconductively. The testing voltage is connected to the leads and the motor winding according to DIN 44081 and DIN VDE 0530.

resistance test of the installed thermistors

Because of the self-heating effect a method to measure PTC-thermistors must be used in which the voltage drop per sensor is not greater than 2,5V DC. The measurement is to be done with a measuring bridge, e.g. Wheatstone. A reading of ≤ 250 Ω per sensor indicates that the sensors and leads are correctly installed. When more than 1 sensor is wired in series the allowable resistance is in multiples of ≤ 250 Ω.

installation instructions for electric motors

It is important that the sensors are inserted in the stator coils, nearest to the rotor before impregnating the windings. The sensors should be tested prior to the impregnation of the rotor, winding temperatures must not exceed 175°C for sensors with ROT 160°C or 185°C for sensors with ROT 170°C. If impregnating agents or impregnating varnishes are used, that are not chemically neutral, the resistivity of the sensors has to be tested by the user. The sensor must be inserted in the middle of the end coils, ensuring that they are completely surrounded by the windings. Hollow space and trapped air influence the heat transmission. One sensor must be inserted into each leg of the windings with the leads parallel to the coil conductors. The mounting of several sensors has to be done in series. The leads must be connected to a terminal block on the terminal board, to ensure that they are separate from the winding terminals. Tension and other mechanical stresses must be avoided when installing sensors. Please avoid loops in the leads to avoid possibly occurring interfering voltage.

Quality control

Unless requested otherwise, quality control is to DIN 40080, AQL (acceptable quality level) in accordance with MIL-standard 105D and IEC 410 at the discretion of the manufacturer. Precise manufacturing and testing techniques guarantee the accuracy of SEVA-tec-PTC-thermistors. All manufacturing operations are designed to conform to DIN 44081 + 44082.
Special versions (e.g. longer leads) are quickly available on request.

Caution:
The lead ends of the PTC-thermistors must not be connected to a voltage larger than 2,5 V DC!
We recommend that a warning label be fixed to any apparatus where there is a possibility of more than 2,5 V DC being connected to the sensor. These warning labels may be purchased from SEVA-tec when required.

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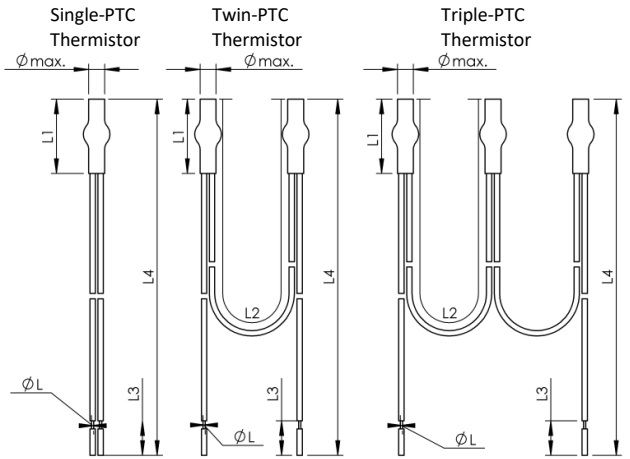
Motor and machine protection

Temperature monitoring with PTC-thermistors



Technical information, color coding of leads and ordering codes for PTC thermistors:

Rated operating Temperature ± Tolerance $T_{ROT} \pm \Delta T_{ROT}$ [°C]	Resistance R [Ω] [1] from -20°C to T_{ROT} -20K	Resistence R [Ω] [1] at PTC-thermistor temperature: $T_{ROT} - \Delta T_{ROT}$ ($U_{KL} \leq 2,5$ V)	$T_{ROT} + \Delta T_{ROT}$ ($U_{KL} \leq 2,5$ V)	$T_{ROT} + 15K$ ($U_{KL} \leq 7,5$ V)	color coding leads-in		order reference [2] single sensor	twin sensor	triple sensor	screw-in-sensor	surface sensor
60 ± 5	≤ 100	≤ 570	≥ 570	-	white	grey	31-K1x5	31-KZ2x5	31-KD3x5	31-G1x5	31-GO1x5
70 ± 5		≤ 570	≥ 570	-	white	brown	41-K1x5	41-KZ2x5	41-KD3x5	41-G1x5	41-GO1x5
80 ± 5		≤ 570	≥ 570	-	white	white	51-K1x5	51-KZ2x5	51-KD3x5	51-G1x5	51-GO1x5
90 ± 5		≤ 550	≥ 1330	≥ 4000	green	green	61-K1x5	61-KZ2x5	61-KD3x5	61-G1x5	61-GO1x5
100 ± 5		≤ 550	≥ 1330	≥ 4000	red	red	71-K1x5	71-KZ2x5	71-KD3x5	71-G1x5	71-GO1x5
110 ± 5		≤ 550	≥ 1330	≥ 4000	brown	brown	81-K1x5	81-KZ2x5	81-KD3x5	81-G1x5	81-GO1x5
120 ± 5		≤ 550	≥ 1330	≥ 4000	grey	grey	91-K1x5	91-KZ2x5	91-KD3x5	91-G1x5	91-GO1x5
130 ± 5		≤ 550	≥ 1330	≥ 4000	blue	blue	101-K1x5	101-KZ2x5	101-KD3x5	101-G1x5	101-GO1x5
140 ± 5		≤ 550	≥ 1330	≥ 4000	white	blue	111-K1x5	111-KZ2x5	111-KD3x5	111-G1x5	111-GO1x5
145 ± 5		≤ 550	≥ 1330	≥ 4000	white	black	116-K1x5	116-KZ2x5	116-KD3x5	116-G1x5	116-GO1x5
150 ± 5		≤ 550	≥ 1330	≥ 4000	black	black	121-K1x5	121-KZ2x5	121-KD3x5	121-G1x5	121-GO1x5
155 ± 5		≤ 550	≥ 1330	≥ 4000	blue	black	126-K1x5	126-KZ2x5	126-KD3x5	126-G1x5	126-GO1x5
160 ± 5		≤ 550	≥ 1330	≥ 4000	blue	red	131-K1x5	131-KZ2x5	131-KD3x5	131-G1x5	131-GO1x5
170 ± 7		≤ 570	≥ 570	-	white	green	141-K1x5	141-KZ2x5	141-KD3x5	141-G1x5	141-GO1x5
180 ± 7		≤ 570	≥ 570	-	white	red	151-K1x5	151-KZ2x5	151-KD3x5	151-G1x5	151-GO1x5
190 ± 7 [3]		≤ 570	≥ 570	-	-	-	-	-	-	-	-
200 ± 7 [3]		≤ 570	≥ 570	-	-	-	-	-	-	-	-
210 ± 7 [3]		≤ 570	≥ 570	-	-	-	-	-	-	-	-

Legend:

1. *Resistance value is given for single PTC-thermistors, the value is to be multiplied for twin, triple and multiple sets.*
2. *Please replace the „x“ in the order reference: for the standard-PTC-form by „5“, for the miniature-PTC-form by „3“.*
3. *The sensor types ROT 190°C, 200°C and 210°C did not meet the standard DIN 44081 and DIN 44082 and thus are not subordinated to the standardized characteristic curves and the color coding.*

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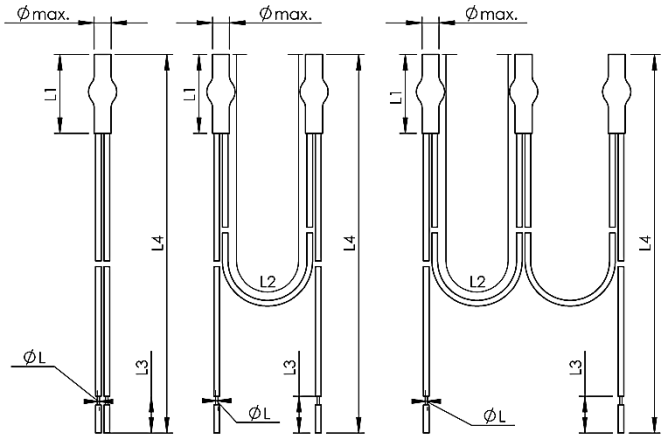
Example models:

PTC-model	dimensions: other design and change of length of leads (L4) according to customer‘s requirements					
	L1 [mm]	L2 [mm] / colour	L3 [mm]	L4 [mm]	Ømax. [mm]	ØL [mm] (according to choice of producer)
standard	15	180 / black	10	520	3,5	0,42 / 0,54
mini	11	180 / yellow	10	520	2,5	0,42 / 0,54

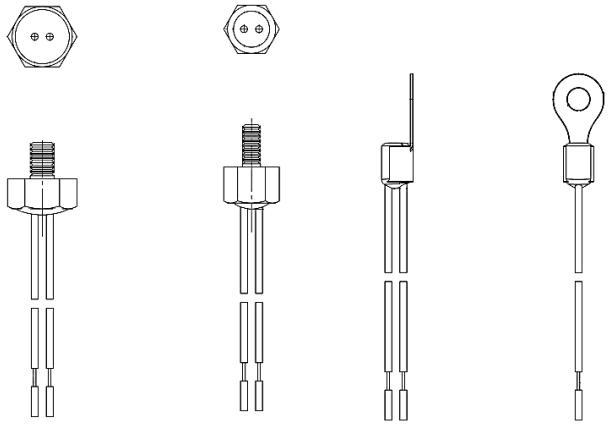
Electric motor- and machine protection
to DIN 44081 und DIN 44082

Single-PTC Thermistor | Twin-PTC Thermistor | Triple-PTC Thermistor



PTC-thermistors for measurements and control 30V

PTC-screw-in sensor | PTC-surface sensor



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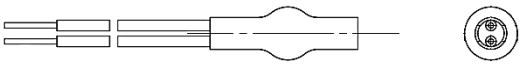
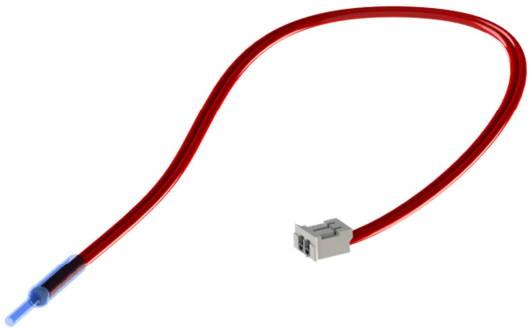
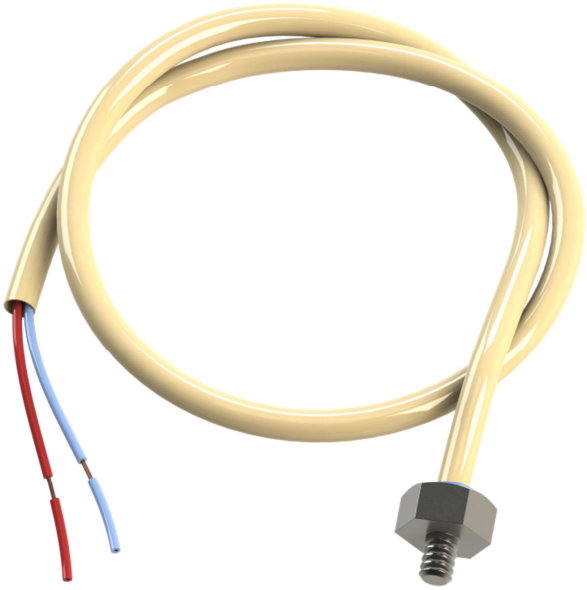
- PTC-sensors

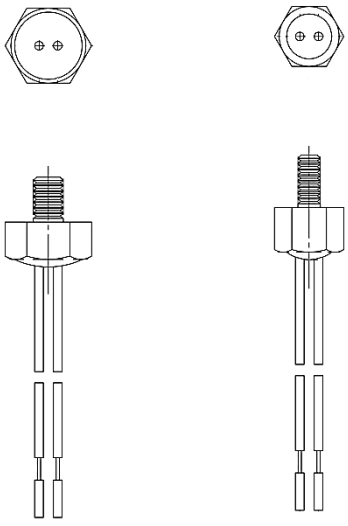
examples of PTC-thermistor-housings



shrink tube housing,
e.g. for monitoring windings

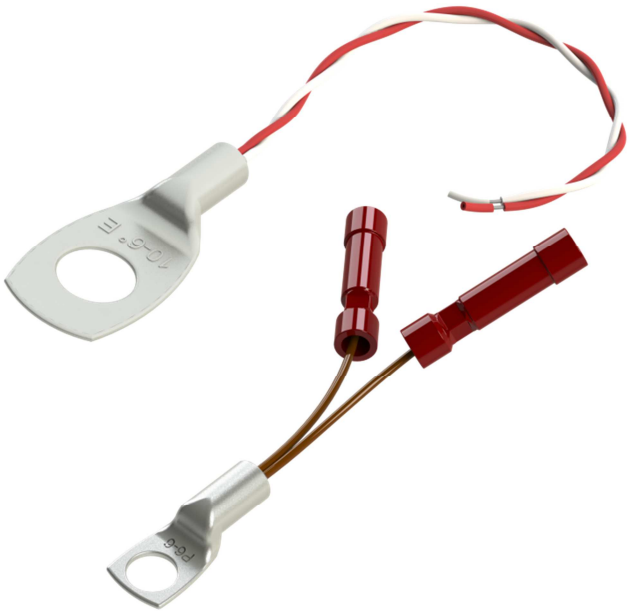


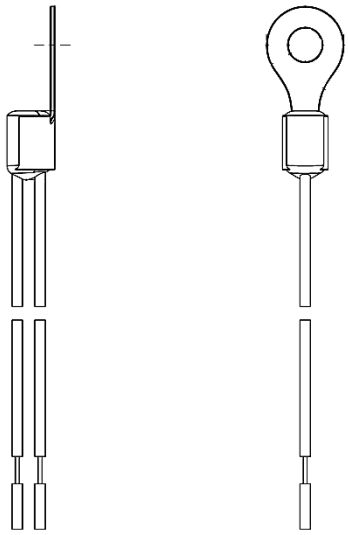




screw-in-sensors in alu housing:
AL-M3/SW8 and AL-M4/SW10

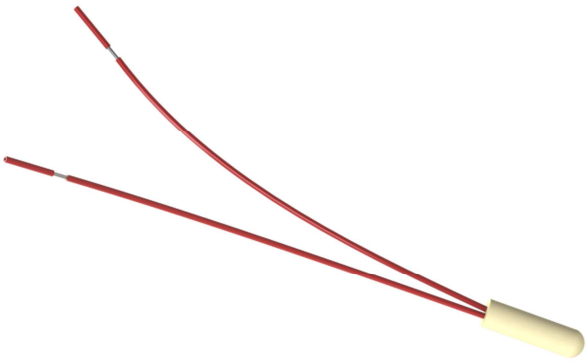
Temperature monitoring with PTC-thermistors

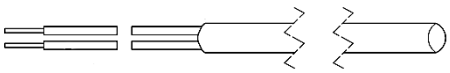




PTC-thermistor in cable shoe
surface sensor

PTC-thermistor in stainless steel housing





PTC-thermistor in ceramics
or brass housing

Responsibility:
No responsibility will be accepted for thermistors which have not been installed and tested according to the relevant standards as previously listed in our data sheet.
Due to the ongoing research and development program, product specification may be subject to change, at the manufacturers discretion.

For further advice and information contact: