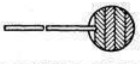
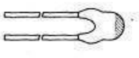
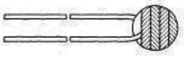
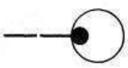
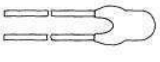
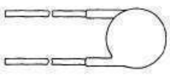
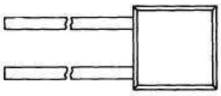
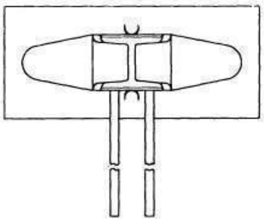
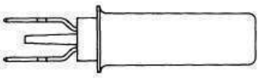
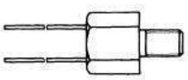
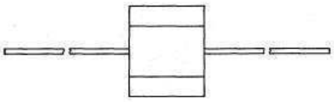
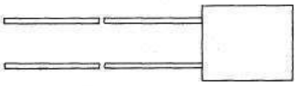
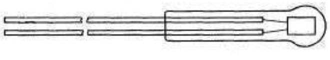
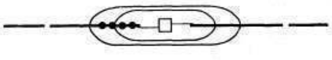
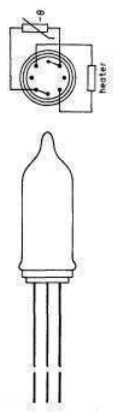
NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

TYPE SELECTION

type		P_{max} W	temp. range at zero power °C	$B_{25/85}$-value K	R_{25} Ω	catalogue number	page
DISC		1	−25 to + 125	2800 to 5450 ± 5%	4 to 1300	2322 610 1	27
			25 to + 100 −25 to + 155	2975	930 5	2322 611 90027 2322 644 90012	32 117
		0,25	−25 to + 125	3660 to 4150 ± 5%	2,7 k to 330 k	2322 640 1	65
		0,25	−55 to + 85	4000	R_{-30} = 50 000 R_{-10} = 15 000 R_{-10} = 15 000 R_{+25} = 2 700	2322 640 90012 2322 640 90014	88 94
		0,5	−25 to + 125	2675 to 4650 ± 5%	3,3 to 470 k	2322 642 6	101
			−25 to + 155	4650 3350	82 min. 15	2322 644 90004 2322 644 90005	111 111
		0,1	−40 to + 110	3965 ±1,25%	5 k to 10 k	2322 645	119
		0,25 0,75	−40 to + 110	3965 ±1,25%	1 k to 5 k		

moulded						
	0,25	−55 to + 85	4000	R_{-30} = 50 000 R_{-10} = 15 000	2322 640 90013 2322 640 98013	90 90
	0,25	−55 to + 85	4000	R_{-10} = 15 000 R_{+25} = 2 700	2322 640 90015 2322 640 98015	97 97
	0,25	−10 to + 125	3750	R_{+25} = 12 000 R_{+100} = 950	2322 640 90004 2322 640 98004	71 71
	0,25	−25 to + 200	4300	R_{+100} = 16 700 R_{+200} = 1 120	2322 640 90005 2322 640 98005	77 77
in special housing						
	0,25	−25 to + 110	3700 3720	R_{+25} = 12 k R_{+90} = 1300	2322 640 90007 2322 640 90021	83 83
	0,5	−25 to + 100	2675 to 4650 ± 5%	3,3 to 470 k	2322 642 7	108
ROD						
	0,1	+ 25 to + 300		220 k	2322 633 7. 224	57

type	P_{max} W	temp. range at zero power °C	$B_{25/85}$-value ± 5% K	R_{25} Ω	catalogue number	page
MINIATURE BEAD						
		−55 to + 200	2075 to 4100	1k to 1M	2322 633 0	47
		−55 to + 200	2075 to 4100	1k to 1M	2322 633 1	47
glass encapsulated						
	0,1	−25 to + 200/300	2075 to 4100	1k to 1M	2322 626 1	33
	0,1	−55 to + 200/300	2075 to 4100	1k to 1M	2322 626 2	39
	0,06	−55 to + 200	2075 to 4100	1k to 1M	2322 633 2	51

INDIRECTLY HEATED  	0,015	−25 to + 85	3860	15k	2322 628 90016	44

INTRODUCTION

NTC thermistors are resistors with a high negative temperature coefficient of resistance. They are manufactured from oxides of the iron group of transition elements e.g. Cr, Mn, Fe, Co or Ni.
These oxides have a high resistivity in the pure state, but can be transformed into semiconductors by adding small amounts of foreign ions which have a different valency.

Examples are:

a. iron oxide Fe_2O_3, where a small part of the Fe^{3+}-ions are replaced by Ti^{4+}-ions. These Ti^{4+}-ions are compensated by an equal amount of Fe^{2+}-ions in order to maintain electroneutrality. At low temperatures the extra electrons of the Fe^{2+}-ions are situated on Fe-ions next to the Ti^{4+}-ions, but at higher temperatures they are gradually loosened from these sites and contribute to the conductivity. In this case we have obtained an electron- or n-type semiconductor.

b. Nickel oxide NiO, or cobalt oxide CoO, with a partial substitution of Li^{1+}-ions for the Ni^{2+}- or Co^{2+}-ions. In this case the Li^{1+}-ions are compensated by an equal amount of Ni^{3+}- or Co^{3+}-ions. At low temperatures the so-called electron-holes (missing electrons) of the trivalent ions are near the foreign ions and again free to move through the crystals at higher temperatures. In this case a positively charged particle is the mobile charge carrier and therefore these materials are called p-type semiconductors.

Stabilizing oxides are sometimes added to achieve improved reproducibility and stability of the characteristics. Which of these compositions is used depends entirely on the required temperature coefficient and the specific resistance.

In examples a. and b. the conductivity σ of the materials can be generally described by

$$\sigma = n\,e\,\mu$$

where e represents the unit of electric charge and n and μ the concentration and the mobility of the charge carriers respectively.

Both n and μ depend on temperature. For n this dependence is exponential according to a Boltzmann law.

$$n \propto e^{-q_1/kT}$$

where q_1 is related to the electrostatic binding energy of the carriers to the foreign ions. It is uncertain whether the temperature dependence of the mobility is comparable to that of charge carriers in germanium-type semiconductors ($\mu \propto T^{-b}$) or to that of ionic conductors where the ions need a thermal activation energy q_2 for each jump to a neighbour site (hopping process). In the latter case the temperature dependence is described by:

$$\mu \propto \frac{e^{-q_2/kT}}{T} \qquad (\propto = \text{direct proportional to})$$

The total temperature dependence of the conductivity is generally proportional to:

$$\sigma \propto T^{-c} \cdot e^{-(q_1 + q_2)/kT}$$

where q_2 may be zero. In practice the exponential factor is the most important one, so that the resistance variation of these thermistors over a wide temperature range can be represented by:

$$R = A\,e^{B/T}.$$

where R = resistance at absolute temperature T,
A and B are constants for a given resistor and
e = the base of the natural logarithm (e = 2,718).

Resistance is plotted as a function of temperature in Fig. 1, for three types with different values of A and B.

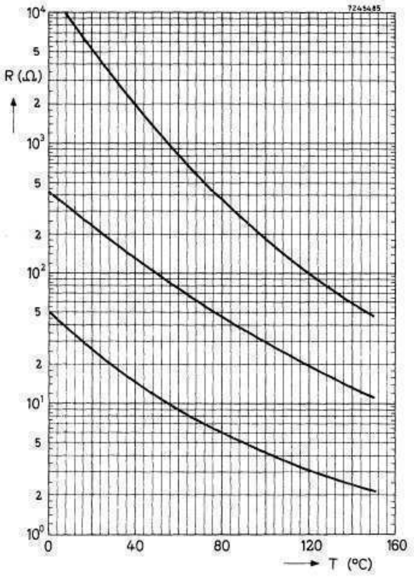


Fig. 1.

MANUFACTURE

The manufacturing process is comparable to that of ceramics. After intensive mixing and addition of a plastic binder, the mass is shaped into the required forms, e.g. by extrusion (rods) or pressing (discs) and fired at a temperature high enough to sinter the constituent oxide. Electrical contacts are then added by burning in with silver paste or by other methods such as electroplating or metal spraying.

Miniature NTC thermistors are made by placing a bead of oxide paste between two parallel platinum alloy wires and then drying and sintering. The platinum alloy wires are 60 μm diameter and 0,25 mm apart. During sintering the bead shrinks onto the wires to make a solid and reliable contact. Miniature NTC thermistors are usually mounted in glass to protect them against aggressive gases and fluids.

APPLICATIONS

According to the essential properties of the NTC their applications may be classified into three main groups:

(I) Applications in which advantage is taken of the dependence of the resistance on the temperature:

$$R = f(T).$$

This group is split into two subsections:

(a) The temperature of the NTC thermistor is determined only by the temperature of the ambient medium (or by the current in a separate heater winding).

(b) The temperature of the NTC thermistor is also determined by the dissipation in the NTC thermistor itself.

(II) Applications in which the time dependence is decisive.
In that case the temperature is considered as a parameter, and is written:

$$R = f(t).$$

This group comprises all applications which make use of the thermal inertia of NTC thermistors.

(III) The third group of applications uses mainly the property of the temperature coefficient being highly negative:

$$\alpha < 0.$$

Also in this group applications are listed which take advantage of the fact that the absolute value of the temperature coefficient is so high, that a part of the $V = f(I)$ curve shows a negative slope.

APPLICATION EXAMPLES

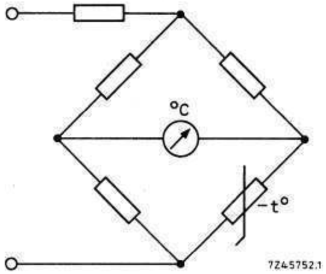


Fig. 12 Temperature measurement in industrial and medical thermometers.

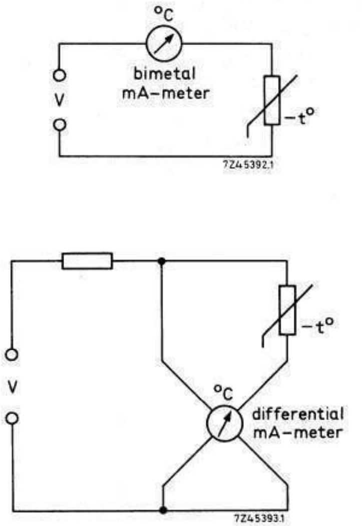


Fig. 13
Temperature measurement in cars.
Cooling water measurements with bimetal or differential milliammeters.

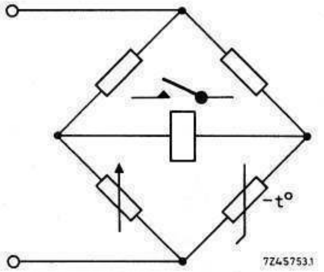


Fig. 14
Temperature control with a bridge incorporating an NTC thermistor and a relay or a static switching device.

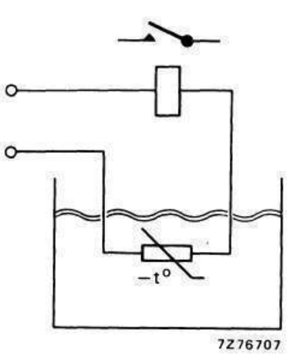


Fig. 15 Liquid level control.

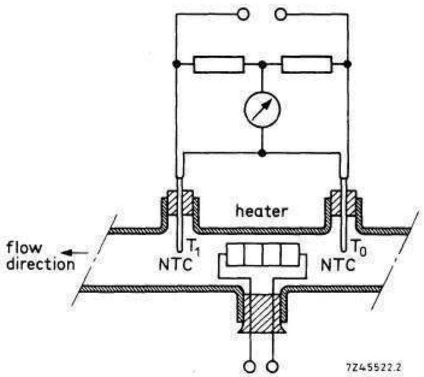
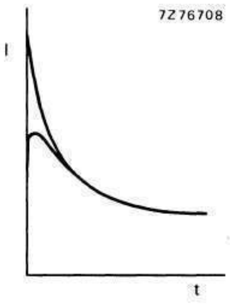


Fig. 16
Flow measurement of liquids. The temperature difference between T_1 and T_0 is a measure for the velocity of the fluid.



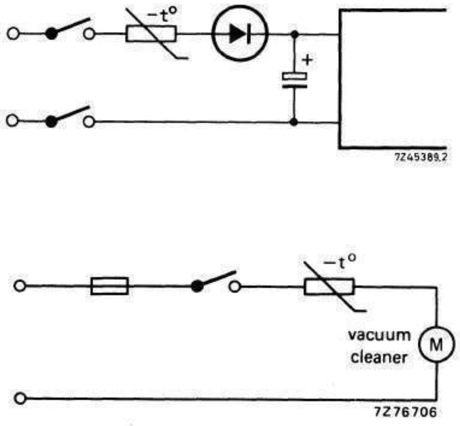
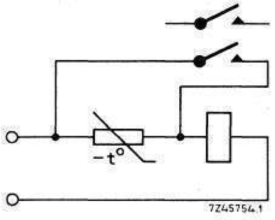


Fig. 17
Inrush current limiter, e.g. for protection of Si-diodes, fuses and switches.

Fig. 18
Delaying action of relays. Due to the thermal inertia of the NTC, it takes some time before the relay is activated. If necessary the NTC can be short-circuited after the relay is activated thus leaving the NTC time for cooling.



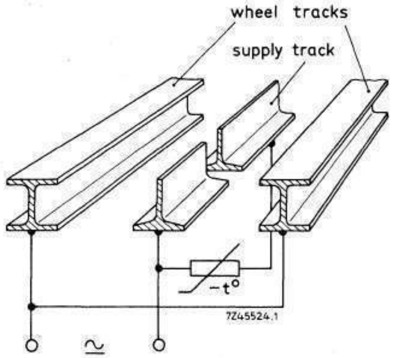
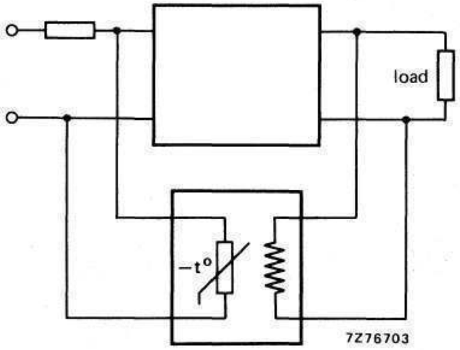


Fig. 19
Model trains. As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

Fig. 20
Gain compensation or gain control with an indirectly heated NTC.



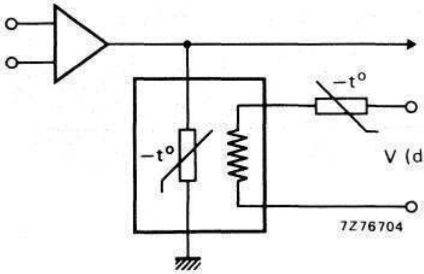


Fig. 21
Compensation for the influence of ambient temperature variations in an h.f. amplifier.

Fig. 22
Temperature compensation in transistor circuits. Push-pull compensation.

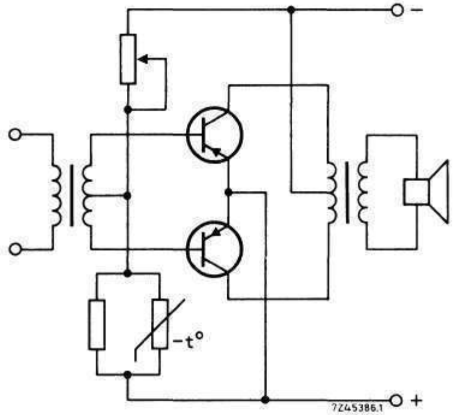


Fig. 23
Transformerless audio output stage with temperature compensation.

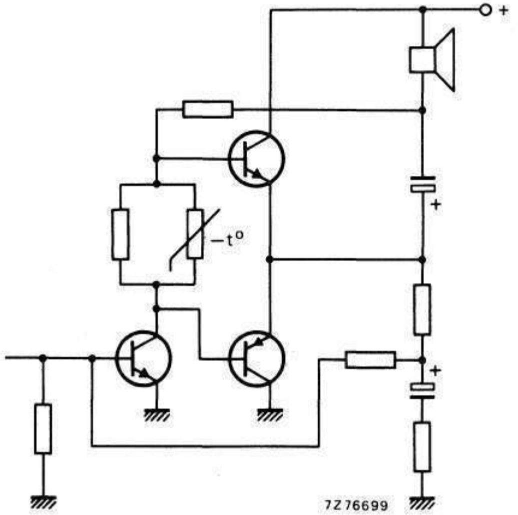


Fig. 24
Stabilization with temperature of an a.g.c. amplifier in a television set.

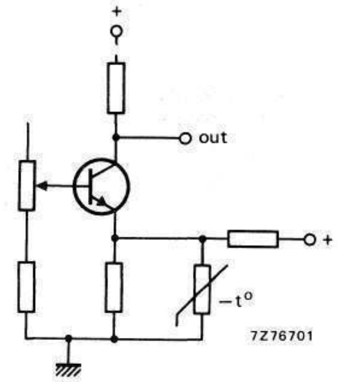


Fig. 25
Compensation of drift in field deflection coils. The influence of the positive temperature coefficient of the copper windings is compensated by means of an NTC thermistor.

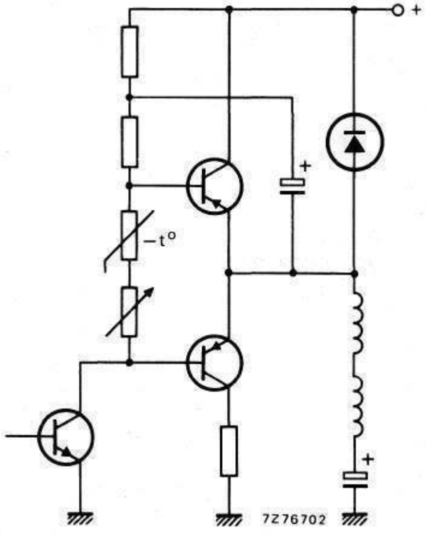


Fig. 26 Simple thermostat.

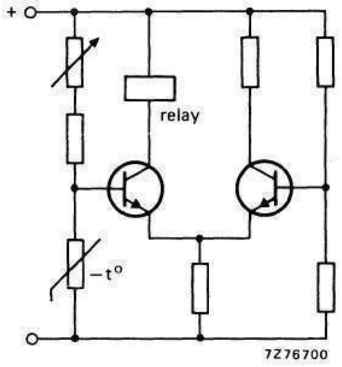
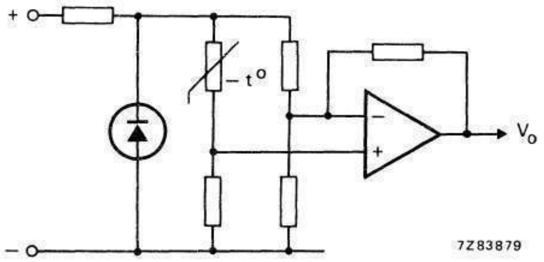


Fig. 27 Temperature sensing bridge with amplifier. The op-amp acts as difference amplifier. The sensitivity can be very high.



NTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance value at + 25 °C	4 to 1300 Ω
$B_{25/85}$-value	2800 to 5450 K
Maximum dissipation	1 W
Dissipation factor	10 mW/K
Thermal time constant	60 s approx.
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose.

DESCRIPTION

Disc thermistor with negative temperature coefficient with two tinned copper wires. It is not lacquered, not insulated and has a colour code.

MECHANICAL DATA

Outlines

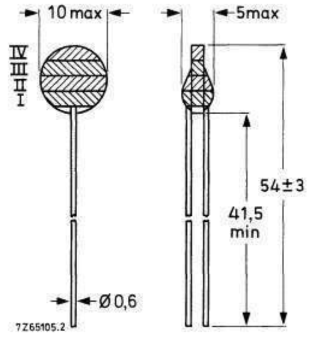


Fig. 1.

Marking (see Fig. 1)

The thermistors are marked with three colour bands showing their resistance value (R_{25}) in code as indicated in the table. Thermistors with a tolerance on R_{25} of 10% have a fourth band in silver.

Mass

1,0 to 1,3 g

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

PACKAGING

250 thermistors in a cardboard box.

ELECTRICAL DATA

Maximum dissipation *	1 W
Dissipation factor *	10 mW/K approx.
Thermal time constant *	60 s approx.
Heat capacity *	0,6 J/K approx.
Operating temperature	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

See further Table 1.

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* Measurements made in still air, between two phosphor-bronze wires (ϕ 1,3 mm).

Table 1 Catalogue numbers 2322 610 1.....

suffix of catalogue number		R_{25}	$B_{25/85}$ ± 5%	temperature coefficient	colour code		
tol. ± 10%	tol. ± 20%	Ω	K	%/K	I	II	III
2408	1408	4	2800	−3,15	yellow	black	gold
2808	1808	8	2900	−3,25	grey	black	gold
2159	1159	15	3125	−3,40	brown	green	black
2339	1339	33	3250	−3,65	orange	orange	black
2509	1509	50	3300	−3,70	green	black	black
2131	1131	130	4600	−5,15	brown	orange	brown
2501	1501	500	5200	−5,85	green	black	brown
2132	1132	1300	5450	−6,15	brown	orange	red

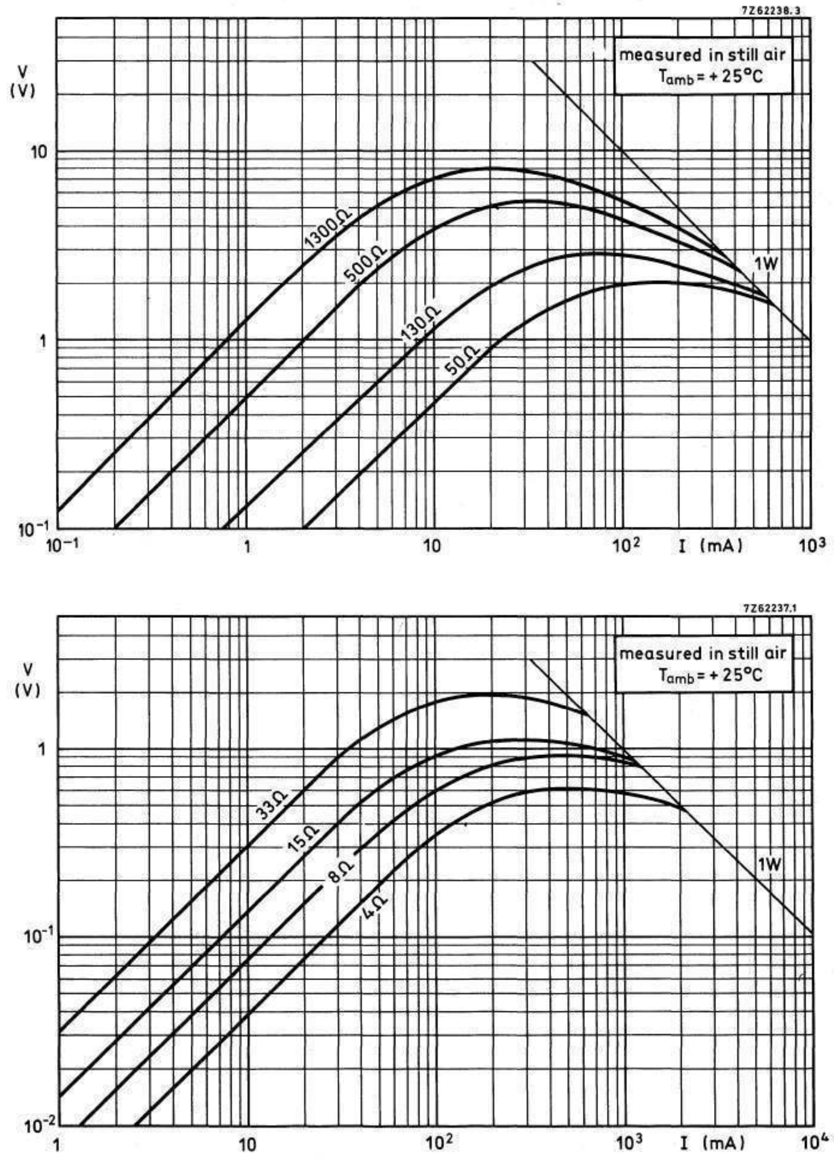
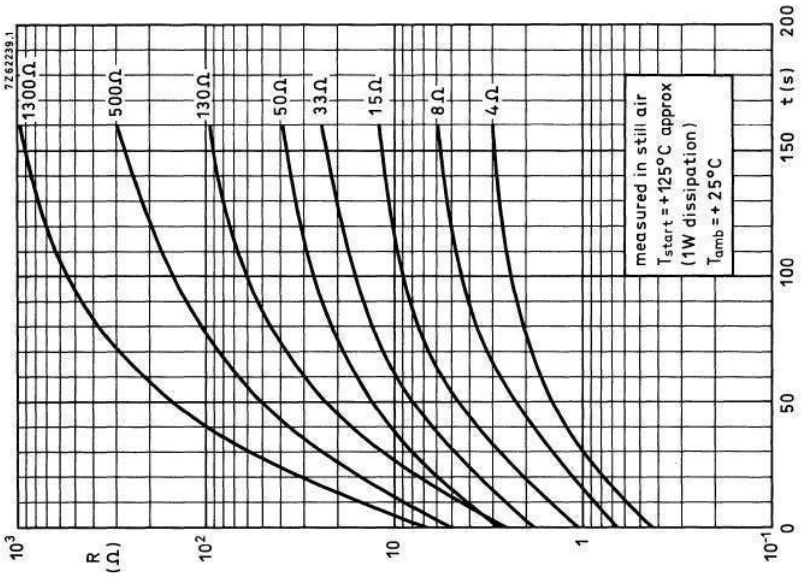


Fig. 2a and b Typical voltage/current characteristics.



measured in still air
T_{start} = +125°C approx
(1W dissipation)
T_{amb} = + 25°C

Fig. 4 Typical resistance/time (cooling) characteristics.

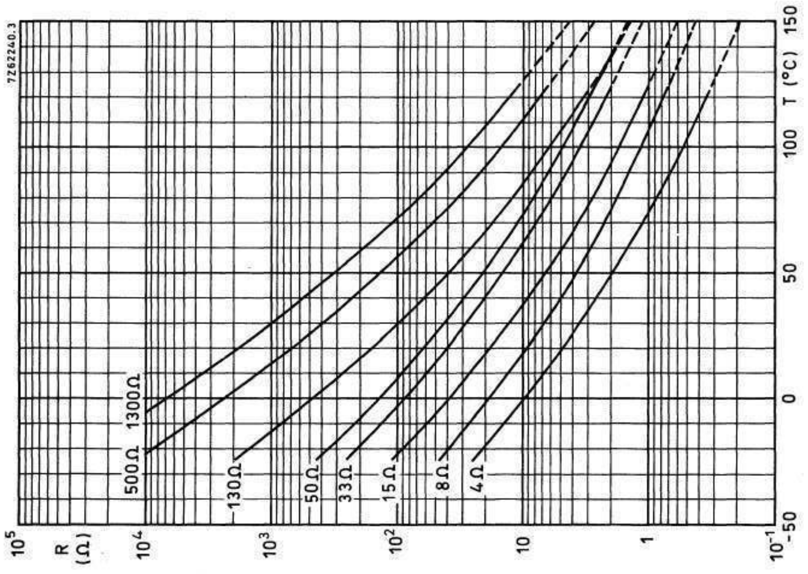


Fig. 3 Typical resistance/temperature characteristics.

NTC THERMISTORS

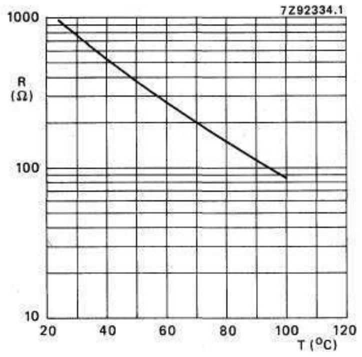
for motor cars

APPLICATION

Temperature sensing for the coolant in motor cars. They are also suitable for temperature control in household appliances, such as washing machines.

DESCRIPTION

Disc thermistors with negative temperature coefficient, without leads. They are specified at a medium temperature (25 °C) and at a higher temperature (100 °C), so that high accuracy at the working temperature is obtained (two-point sensor).



Typical resistance/temperature characteristics.

Catalogue number	2322 611 90027
Diameter	4,5 ± 0,5 mm
R_{25}	930 Ω ± 10%
R_{100}	84,5 Ω ± 7%

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	1 kΩ to 1 MΩ
$B_{25/85}$-value	2075 to 4100 K
Maximum dissipation	100 mW
Dissipation factor	~ 1,2 mW/K
Thermal time constant	~ 10 s
Operating temperature range	
at zero power	−25 to + 200 °C, or + 300 °C
at maximum power	0 to + 55 °C

APPLICATION

Temperature measurement and control up to 300 °C in 'aggressive' environments. Also level sensing. ←

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two tinned dumet (CuNiFe) wires.

MECHANICAL DATA

Outlines

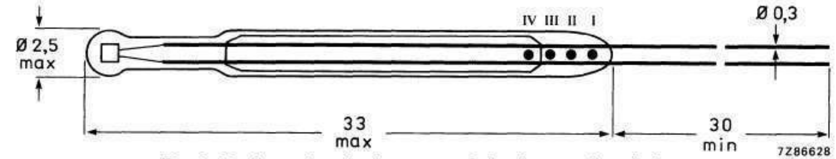


Fig. 1 Maximum bow in the centre of the glass envelope is 1 mm.

Marking

Four colour dots on the glass envelope, see table for colour code.

Mass

0,27 g approximately.

Mounting

In any position by soldering.

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Inflammability

Uninflammable.

Impact

Free fall	100 mm

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N
Resistance to solvents	according to IEC 68-2-45, resistant to R113 at T_{amb}.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Table 1 Catalogue number 2322 626 1....

suffix of the catalogue number			R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code*		
tol. ± 5%	tol. ± 10%	tol. ± 20%	kΩ	K	%/K	I	II	III
3102	2102	1102	1	2075	−2,3	brown	black	red
3222	2222	1222	2,2	2285	−2,6	red	red	red
3472	2472	1472	4,7	2485	−2,8	yellow	violet	red
3103	2103	1103	10	2750	−4,2	brown	black	orange
3223	2223	1223	22	3560	−4,0	red	red	orange
3473	2473	1473	47	3750	−4,2	yellow	violet	orange
3104	2104	1104	100	3900	−4,4	brown	black	yellow
3224	2224	1224	220	3860	−4,3	red	red	yellow
3474	2474	1474	470	3950	−4,5	yellow	violet	yellow
3105	2105	1105	1000	4100	−4,6	brown	black	green

* Thermistors with 5% tolerance have a gold dot IV; 10% tolerance is identified by a silver dot IV, 20% versions have no dot IV (Fig. 1).

Maximum dissipation at + 55 °C	100 mW
Dissipation factor	~ 1,2 mW/K
Thermal time constant	~ 10 s
Response time (see note)	~ 1 s
Operating temperature range (Fig. 2 and Table 1)	
at zero power	−25 to + 200 °C, or + 300 °C
at maximum power	0 to + 55 °C
Dielectric withstanding voltage (r.m.s.) between terminals and glass envelope	min. 1500 V
Insulation resistance between terminals and glass envelope at 100 V (d.c.)	min. 100 MΩ

Note: Response time in silicone oil MS 200/50. The response time in silicone oil is the time necessary to change of 63,2 % of the total difference between the initial and the final body temperature, when subjected to a step function change in ambient temperature. Step change: initial temperature: air at 25 °C; final temperature: oil (MS 200/50) at 85 °C.

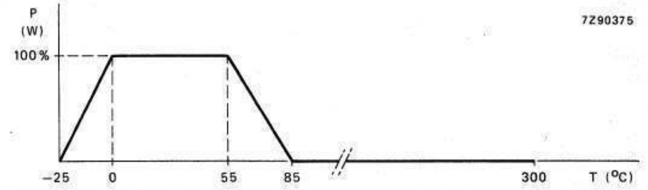


Fig. 2 Derating curve.

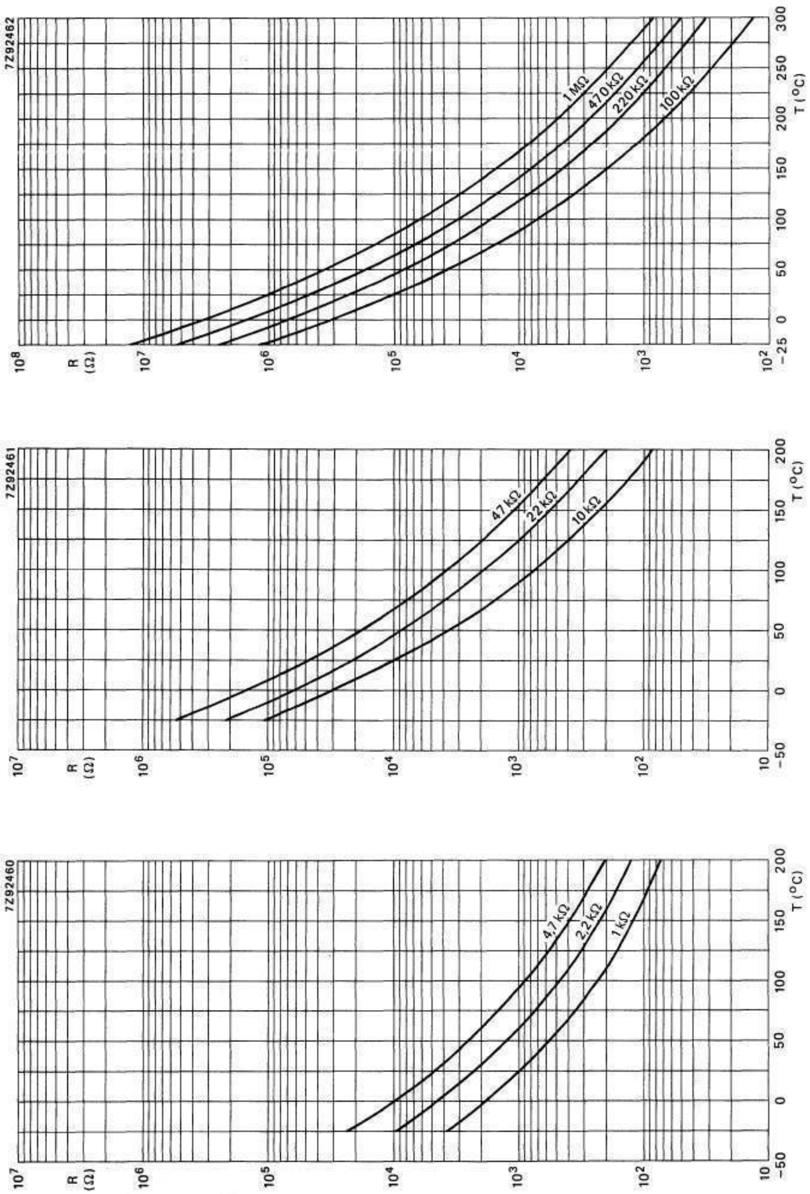


Fig. 3 Typical resistance/temperature characteristics.

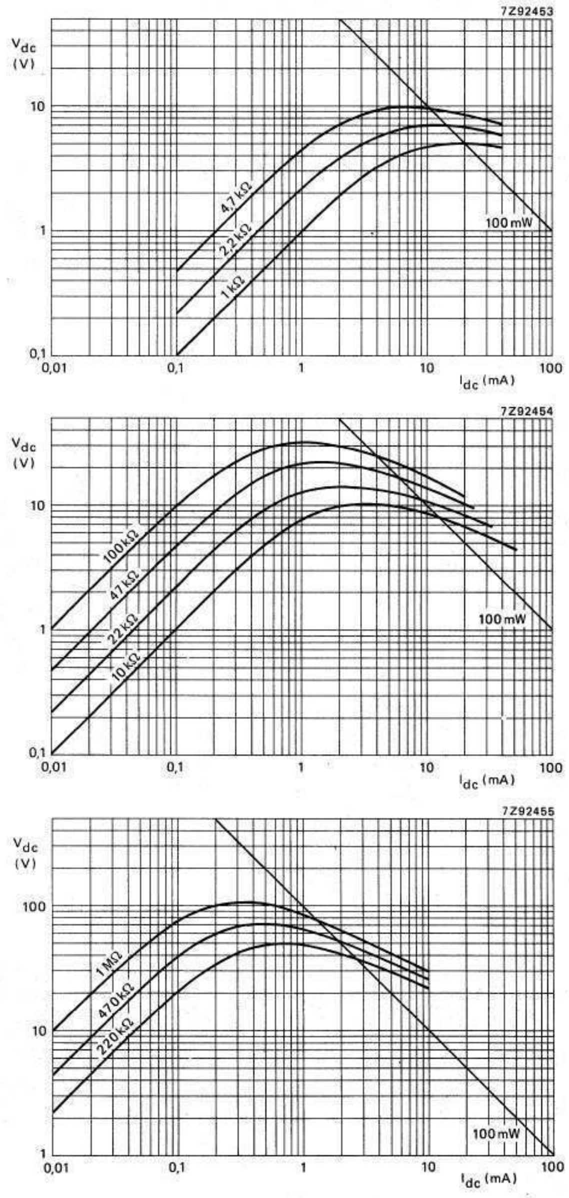


Fig. 4 Typical voltage/current characteristics. Measured in still air at 25 °C.

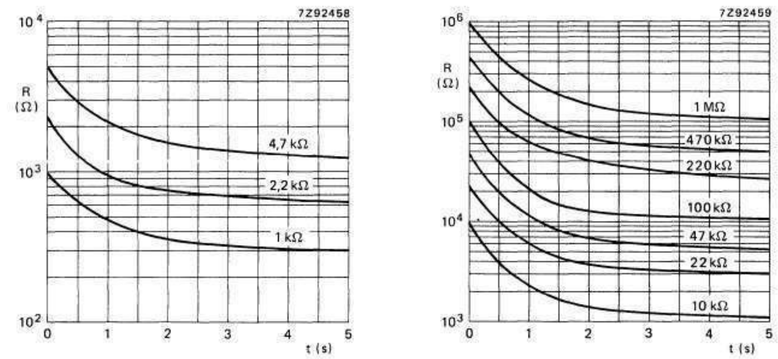


Fig. 5 Typical resistance/response characteristics.
Temperature step from air at 25 °C to oil at 85 °C.

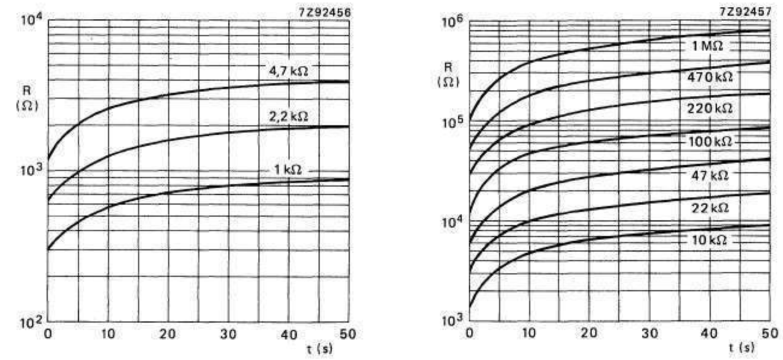
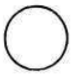
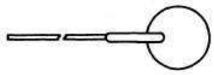
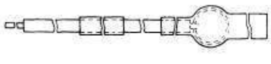
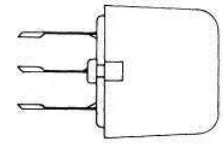
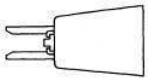
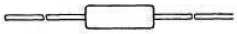


Fig. 6 Typical resistance/cooling time characteristics.
Measured in still air at 25 °C. T_{start} = 85 °C.

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC)

TYPE SELECTION

	maximum voltage	R_{25} Ω	switch temperature °C	dissipation factor mW/K	temperature coefficient %/K	catalogue number	page
DISC 	460 V (r.m.s.)	70 to 100	120	11,5	35	2322 662 93006	174
	25 V (d.c.)	⩾ 4000	70 to 150		18 to 38	2322 672 91026 to 2322 672 91035	221
DISC with leads	16 V (d.c.)	⩽ 0,6	85	27	10	2322 664 91086	215
	25 V (d.c.)	30 to 250	70 to 150	5,7	18 to 38	2322 672 91002 to 2322 672 91035	301
	25 V (d.c.)	50 and 60 ± 30%	30 to 105	7	7 to 40	2322 660 91006 to 2322 660 91009	152
	25 V (d.c.)	250 ± 25%	6	6	5	2322 660 91001	149
	40-50 V (d.c.)	30 to 50 ± 15 Ω	25 to 110	6 to 8,5	9 to 75	2322 661 91002 to 2322 661 91005	163
	180 V (d.c.)	36 to 50	115	13	35	2322 662 91001	168
	245 V (r.m.s.)	750 to 1500	115	7	26	2322 660 93001	159
	265 V (r.m.s.)	45 to 60	75	20	20	2322 662 93036	177
	265 V (r.m.s.)	100 ± 20%	75	15	35	2322 662 93066	181
	25 V (d.c.)	⩾ 4000	70 to 150	5,7	18 to 38	2322 672 91002 to 2322 672 91011	221

Overload protection	56 V (d.c. and 265 V (r.m.s.)					2322 66 .	254 to 303
Loudspeaker protection	18 V (r.m.s.) 18 V (r.m.s.)	max. 1,1 max. 1,1	100 140		6 8	2322 662 91016 2322 663 91006	171 211
Motor protection 	15 V (d.c.)	30 to 250	68 to 137	7	18 to 38	2322 672 92045 to 2322 672 92053	229
DUAL PTC for degaussing 	145 V (r.m.s.)	10 and 400 to 2400	70 and 170		16 and 20	2322 662 98013	201
	265 V (r.m.s.)	40 and 3000				2322 662 98009	185
	265 V (r.m.s.)	35 and 1000	65 and 170	12,5	26 and 19	2322 662 98011	193
	265 V (r.m.s.)	40 and 3000	65 and 170			2322 662 98018	205
DISC for compensation of telephone line variations 	33 V (d.c.)	115 ± 25	97	3,9	10	2322 672 98001	237
	34 V (d.c.)	120 ± 30	145		8	2322 670 90003	219

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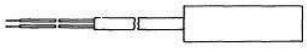
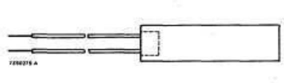
type	voltage range r.m.s. V	max. inrush power W	operating temp. after 20 min °C	measured at V	diameter mm	catalogue number	page
HEATING ELEMENT 	100 to 265	500	–	220	12,7	2322 680 04022	255
	100 to 265	1000	160	220	14,8	2322 680 00031	243
	100 to 265	1000	160	220	10,8	2322 680 03001	245
	100 to 265	1000	215	220	12,7	2322 680 04001	247
	100 to 145	1000	215	220	12,7	2322 680 04002	249
	100 to 265	1000	160	220	12,7	2322 680 04003	251
	100 to 145	1000	160	220	12,7	2322 680 04004	253
	100 to 265	1000	220	220	12,7	2322 680 04022	255
	145 and 265					2322 680 93021 to 2322 680 93037	257

INTRODUCTION

Positive Temperature Coefficient (PTC) thermistors are resistors with a high positive temperature coefficient of resistance. They differ from NTC thermistors in the following aspects:

- The temperature coefficient of a PTC thermistor is positive only *between certain temperatures,* outside this range the temperature coefficient is either zero or negative.
- The absolute value of the temperature coefficient of PTC thermistors is usually much higher than that of NTC thermistors.

PTC thermistors are used as current limiters, temperature sensors and protectors against overheating in equipment such as electric motors. They are also used as level indicators, time delay devices, thermostats, compensation resistors, etc. See chapter 'Applications'.

PTC thermistors are prepared from $BaTiO_3$, or solid solutions of $BaTiO_3$ and $SrTiO_3$ in a similar way as NTC thermistors. Extra electrons on the Ti-ions are created by the introduction of foreign ions having a different valency. In these compounds there are two possibilities: substitution of trivalent ions like La^{3+} or Bi^{3+} for Ba^{3+} or substitution of pentavalent ions like Sb^{5+} or Nb^{5+} for Ti. Both methods lead to identical results. If prepared in the absence of oxygen, these semiconductors have a weakly negative temperature coefficient. A strong positive temperature coefficient is obtained by firing the ceramic samples in an oxygen-rich atmosphere. This is caused by the penetration of oxygen along pores and crystal boundaries during cooling after the firing process. The oxygen atoms, absorbed on the crystal surfaces attract electrons from a thin zone of the semiconducting crystals. In this way electrical potential barriers are formed consisting of a negative surface charge with, on both sides, thin layers having a positive space charge resulting from the now uncompensated foreign ions. These barriers cause an extra resistance of the thermistor.

$$R_b \propto \frac{1}{a} e^{eV_b/kT} \qquad (\propto = \text{directly proportional to})$$

Here 'a' represents the size of the crystallites, thus $\frac{1}{a}$ is the number of barriers per unit length of the thermistor. V_b represents the electrical potential of the barriers. As V_b is inversely proportional to the value of the dielectric constant of the crystals it is clear that R_b is extremely sensitive to variations of the dielectric constant. Such a variability of the dielectric constant is a special property of materials with a ferroelectric nature like $BaTiO_3$ and its solid solutions. Above their ferroelectric Curie temperature θ the relative dielectric constant decreases with temperature according to

$$\epsilon_r = \frac{C}{T - \theta}$$

where C has a value of approximately 10^5 K. As a result the resistivity increases steeply just above the Curie temperature. Below the Curie temperature the barriers are weak or absent, partly as a result of the high effective dielectric constant of $BaTiO_3$ in strong fields and partly as a result of the spontaneous polarization of the crystals which may compensate the boundary charges.

At very high temperatures, i.e. above 160 to 200 °C the electrons captured at the boundaries are gradually liberated, causing the potential barriers to decrease in strength. This means that the PTC loses its properties and may eventually act as an NTC if the temperature becomes too high. Therefore the applications of PTC thermistors are restricted by a certain temperature limit.

As the PTC effect is caused by crystal boundary barriers the extra resistance R_b is shunted by a high parallel capacitance C_b. This leads to a frequency dependence of extra impedance Z_b up to 5 MHz. The characteristic properties described in the following paragraphs are thus restricted to this frequency range.

ELECTRICAL PROPERTIES

RESISTANCE/TEMPERATURE CHARACTERISTICS

Figure 1 shows typical resistance/temperature characteristics of an NTC and a PTC thermistor.

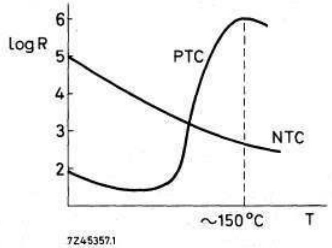


Fig. 1.

VOLTAGE/CURRENT CHARACTERISTICS

Static voltage/current characteristics show the current limiting ability of PTC thermistors. Up to a certain voltage the V/I characteristic follows Ohm's law, but the resistance increases when the PTC is heated so much by the current it is carrying that its temperature reaches the switch temperature. See Fig. 2. Of course the V/I characteristic depends on the ambient temperature and on the heat transfer coefficient to the ambience. In Fig. 2 the characteristic is plotted on a linear scale. In practice, however, logarithmic scales are used more often, see Fig. 3. PTC thermistors show some voltage dependency. At higher voltages the resistance is somewhat lower than expected. It is possible to calculate accurately the top of the V/I characteristic if the R/T characteristic and the dissipation constant are known:

The power dissipation is: $P = I^2 R$

Thus a small increase in P: $\Delta P = 2\,IR\Delta I + I^2 \Delta R$

At the top of the V/I curve $\Delta I_p = 0$, thus:

$\Delta P_p = I_p^2\,\Delta R_p$ (p indicates that the values are taken at the top of the V/I characteristic).

Also $\Delta P = D\Delta T$, thus:

$\Delta P_p = D\Delta T_p = I_p^2\,\Delta R_p$

or $\frac{\Delta T_p}{\Delta R_p} \cdot D = I_p^2$

APPLICATIONS

The applications of PTC thermistors can be classified in two main groups:

- Applications where the temperature of the PTC is primary determined by the temperature of the ambient medium.
- Applications where the temperature of the PTC is primary determined by the current through the PTC thermistor.

The first group comprises applications such as temperature-measurement and control and circuits for protection against excessive temperatures (e.g. motor protection.)

The second group includes applications such as current stabilization and current sensitive switching or overload protection, relay retardation, fluid-level indication and circuits for protection against over-voltages and short circuits. Also heating applications.

ADVICE

Do not apply a voltage above V_{max} to the PTC, since this may destroy the thermistor.

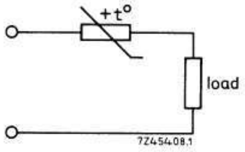
Do not connect PTC thermistors in series in order to obtain higher voltages or wattages: this may cause one PTC to heat up faster than the other(s) resulting in too high a voltage across this particular PTC.

If special PTC characteristics are required which cannot be found in this book please specify your requirements as they can perhaps be fulfilled by one of our non-listed types.

APPLICATION EXAMPLES

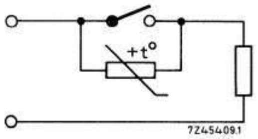
Protection against over-load or current sensitive switching

As soon as the current increases the PTC limits it to a safe value.



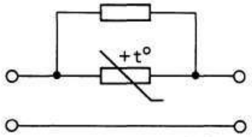
Spark suppression

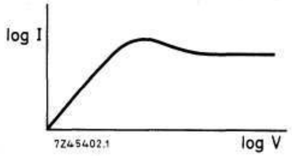
A PTC across the switch acts as a spark suppressor. When the switch opens the low resistance of the cold PTC prevents sparking.



Current stabilization

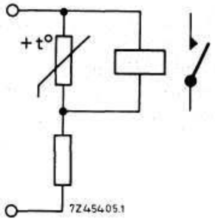
By using a parallel resistor a current stabilization circuit is obtained that compensates slowly varying supply voltages.





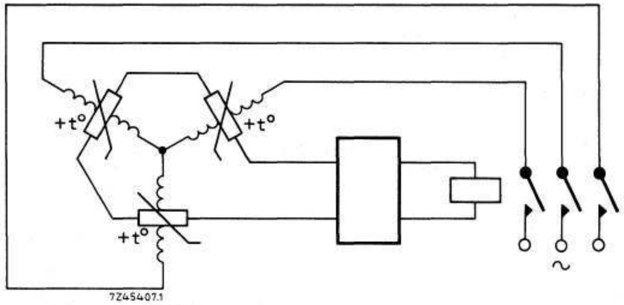
Delaying action relays

A certain time after applying the voltage the relay is activated.



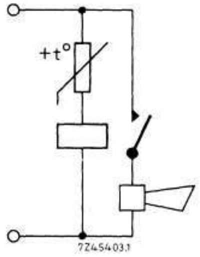
Temperature protection of electric motors

As soon as one or more windings become too hot the motor is switched-off.



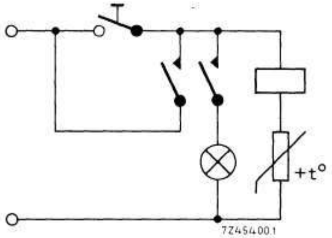
Alarm installation

The PTC reacts on ambient temperature (too low or too high).



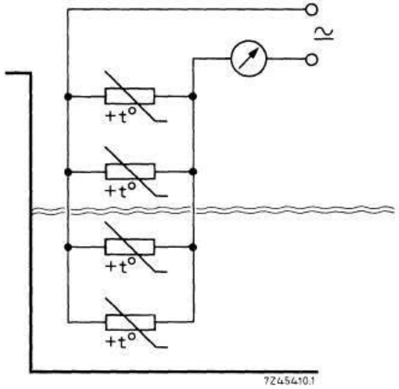
Time delay circuit

When the button is pressed the relay is activated and the lamp lights up. After some time the relay falls off due to the increase in resistance of the PTC.

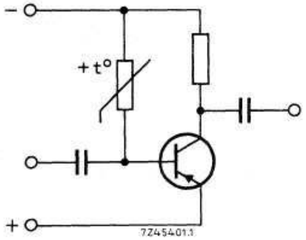


Liquid-level indication

The PTC thermistors above the fluid-level will be heated to a temperature above T_{switch}. When immersed they are cooled so that their resistance reduces.

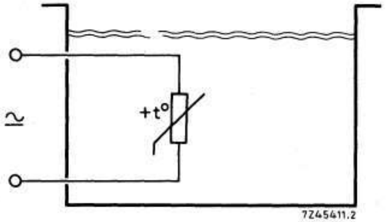


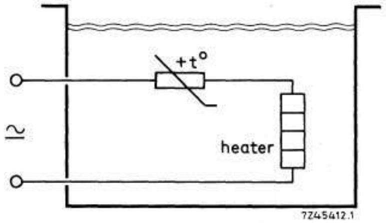
Temperature compensation of transistor circuits



Thermostatically-controlled heating circuits

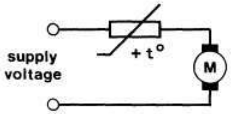
Two principal circuits are possible. In the first circuit the PTC thermistor acts as a control element and as a heater at the same time, while in the second circuit it functions only as a control element.





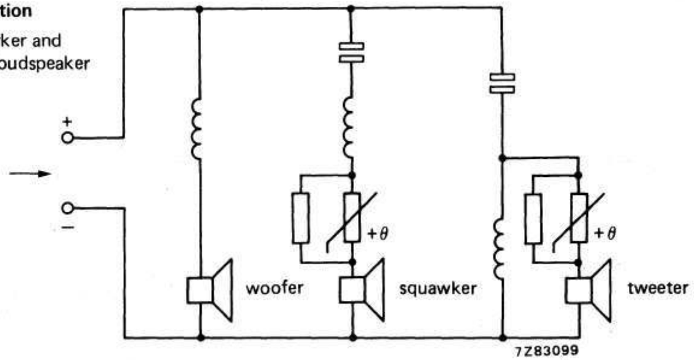
Protection of a stalled electric motor against overheating.

The increased current heats the PTC to its switch temperature. As a result the total dissipated power is reduced to a safe value.



Loudspeaker protection

Protection of squawker and tweeter in a 3-way loudspeaker system.



PTC THERMISTOR

disc

QUICK REFERENCE DATA

Resistance value at +25 °C	250 Ω ± 25%
Resistance value at +80 °C	3700 Ω ± 30%
Switch temperature	+6 °C approx.
Temperature coefficient	+5%/K approx.
Max. voltage at T_{amb} = +55 °C	25 V d.c.
Dissipation factor	6 mW/K approx.
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +55 °C

APPLICATION

Temperature compensating and temperature measurement purposes.

DESCRIPTION

The thermistor has a positive temperature coefficient. It consists of a disc with two tinned copper wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Outlines

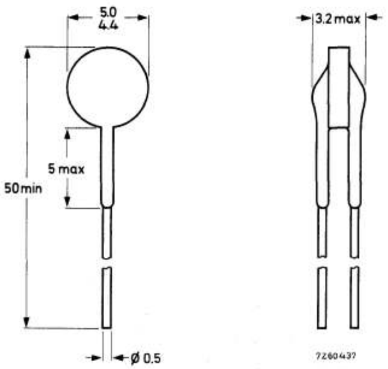


Fig. 1.

Mass 0,3 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

ELECTRICAL DATA

Resistance *		
at +25 °C (T_{ref})		250 Ω ± 25%
at +80 °C		3700 Ω ± 30%
Switch temperature	~	+6 °C
Temperature coefficient	~	+5%/K
Dissipation factor **	~	6 mW/K
Heat capacity **	~	0,1 J/K
Thermal time constant **	~	17 s
Operating temperature range		
at zero power		−25 to +155 °C
at V_{max}		0 to +55 °C
Voltage dependence at +155 °C		0,25 approx.
Balance voltage (d.c.)		13 V approx.
Maximum voltage (d.c.)		25 V

PACKAGING

500 thermistors in a cardboard box.

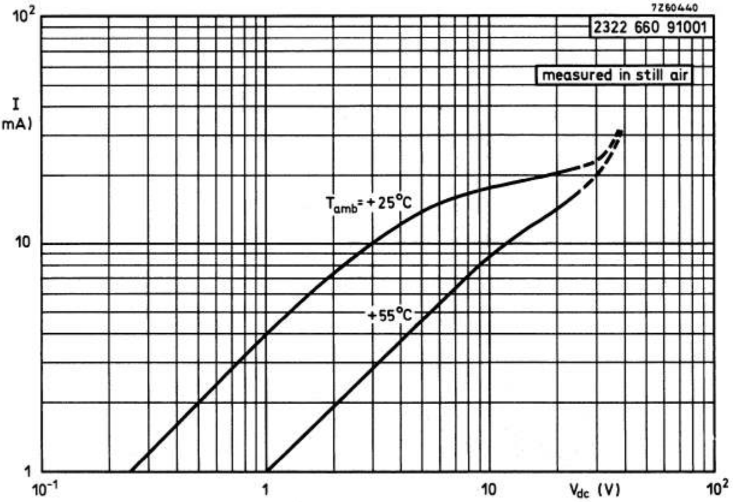


Fig. 2 Typical current/voltage characteristics.

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* Measuring voltage not exceeding 1,5 V(d.c.) to avoid internal heating.

** Measurement made with specimen in phosphor bronze clips in still air.

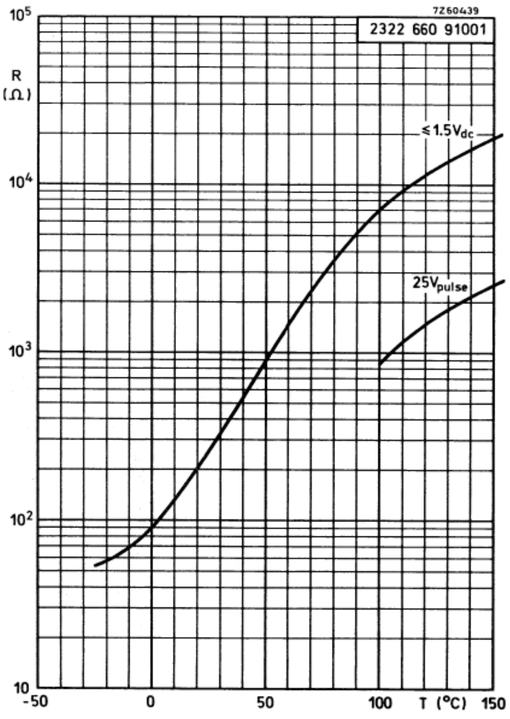

Fig. 3 Typical resistance/temperature characteristics.

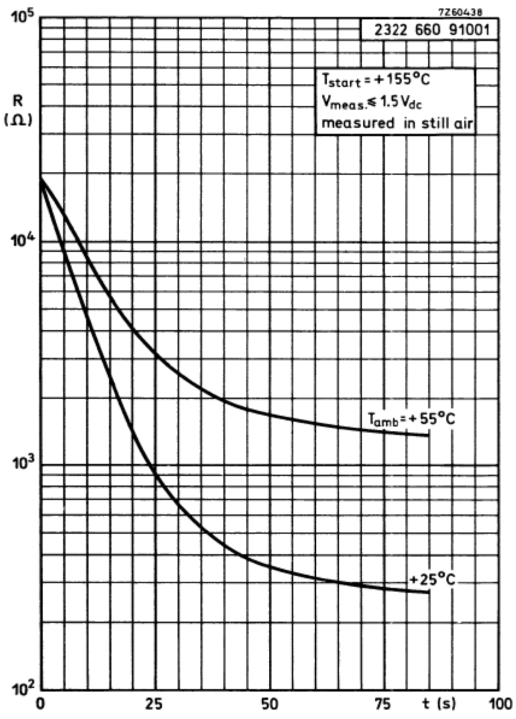

Fig. 4 Typical resistance/time (cooling) characteristics.

PTC THERMISTOR

disc

QUICK REFERENCE DATA

Resistance	
at +25 °C	100 Ω ± 20%
at +155 °C	
V_{pulse} = 380 V	⩾ 40 kΩ
Switch temperature	75 °C
Temperature coefficient	+ 35%/K
Maximum r.m.s. voltage	265 V
Dissipation factor	~ 15 mW/K
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +60 °C

APPLICATION

In degaussing circuits of colour television sets.

DESCRIPTION

This thermistor has a positive temperature coefficient. It consists of a disc with two tinned brass wires. The thermistor body is not lacquered.

MECHANICAL DATA

Outlines

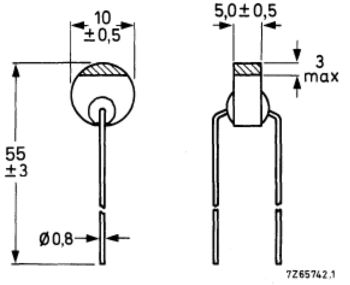

Fig. 1.

Marking	The thermistor is marked with a red colour band on top of the body.
Mass	2,7 g approx.
Mounting	In any position by soldering at min 15 mm from the body.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

All values in the table without further indication are approximate values.

Resistance value	
at +25 °C *	100 Ω ± 20%
at +72 °C *	< 2 x R_{25}
at +85 °C *	> 2 x R_{25}
at +155 °C and V_{pulse} = 380 V **	⩾ 40 kΩ
Switch temperature	+75 °C
Temperature coefficient	+35%/K
Maximum r.m.s. voltage, with series resistor of 33 Ω	265 V
Dissipation factor ***	15,3 mW/K
Thermal time constant ***	80 s
Heat capacity of complete thermistor ***	1,2 J/K
Balance voltage (d.c.)	190 V
Voltage dependence at 155 °C	0,26
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +60 °C

* Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating.
** Measurement made without internal heating.
*** Measurement made with specimen in phosphor bronze clips, in still air.

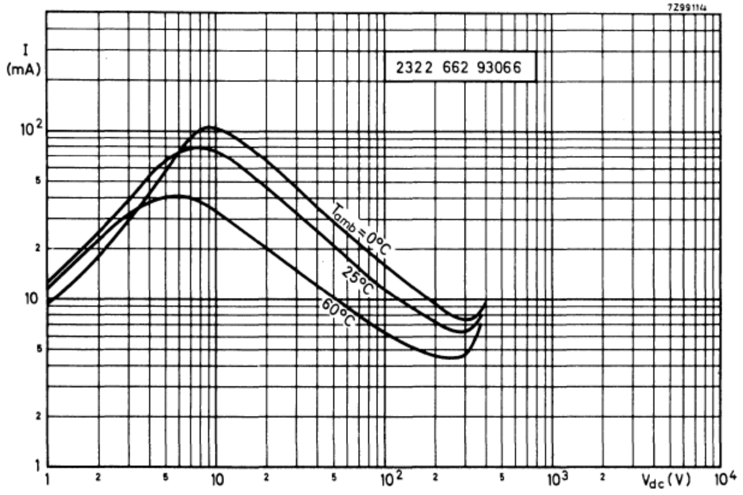

Fig. 3 Typical voltage/current characteristics.

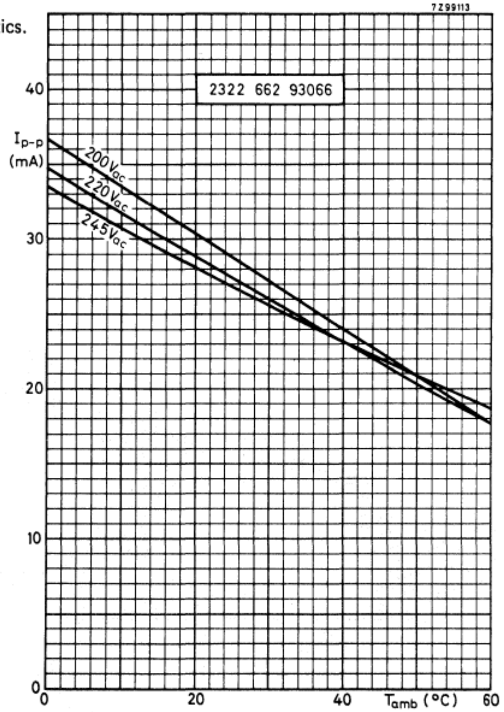

Fig. 4 Typical characteristics of peak to peak current against the ambient temperature at different voltages.

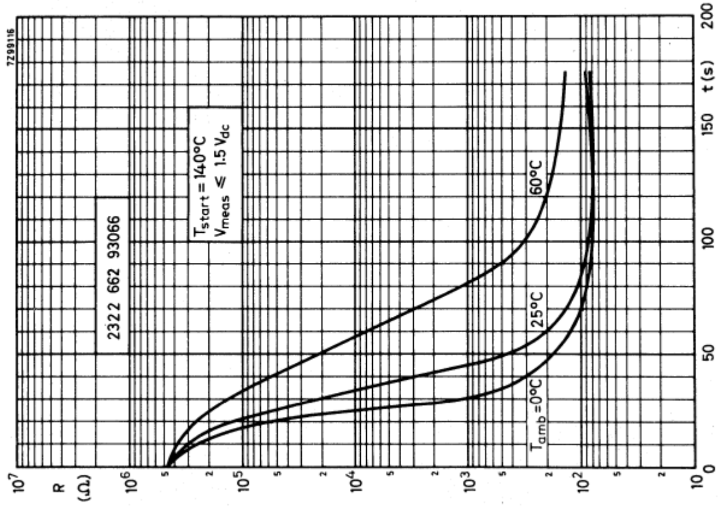

Fig. 6 Typical resistance/time (cooling) characteristics.

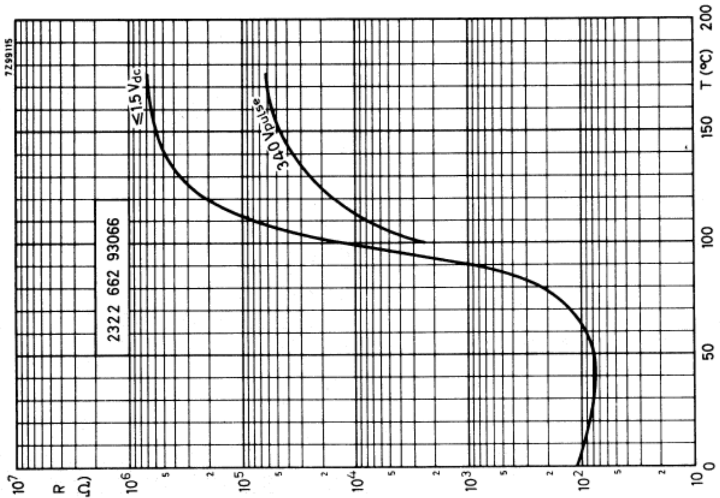

Fig. 5 Typical resistance/temperature characteristics.