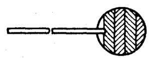
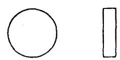
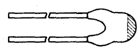
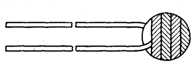
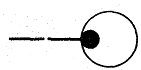
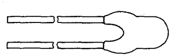
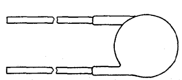
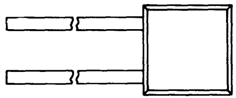
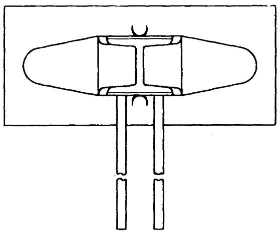
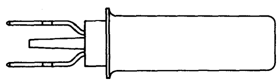
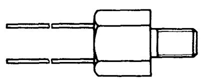
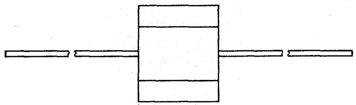
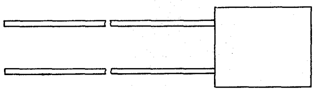
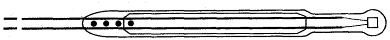
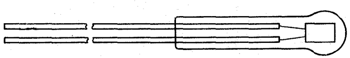
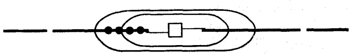
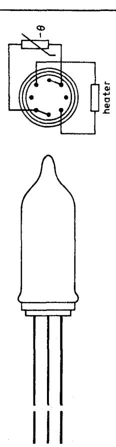
TYPE SELECTION

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 ^oC	$B_{25/85}$-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.

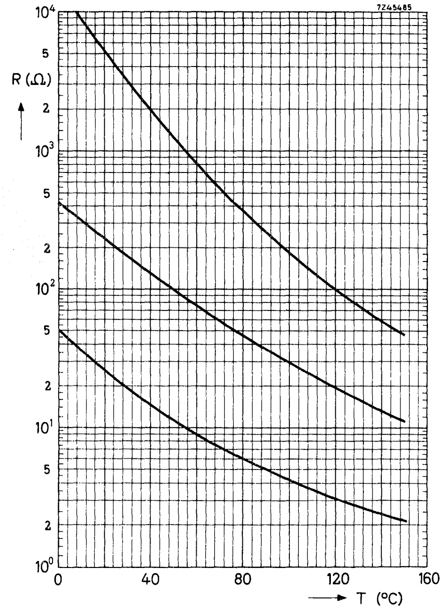


Fig. 1.

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.

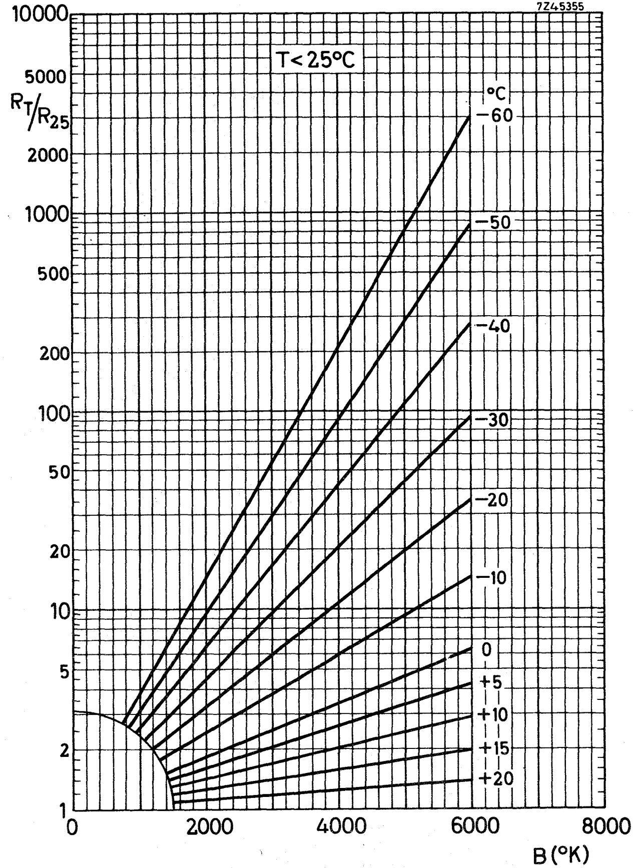


Fig. 2 R_T/R_{25} as a function of B-value with temperature as a parameter.

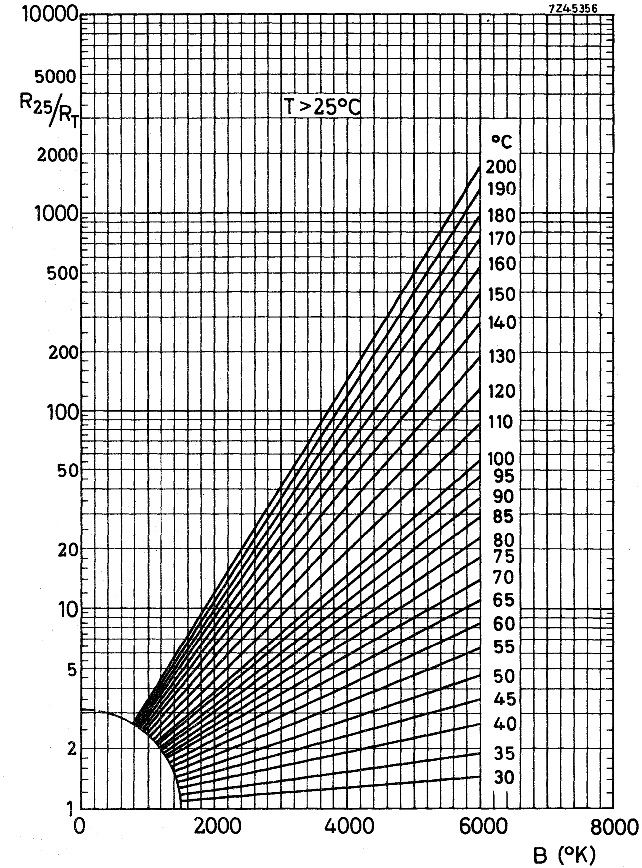


Fig. 3 R_{25}/R_T as a function of B-value with temperature as a parameter.

For a particular NTC thermistor the value of B may be found as follows. The resistance value is measured at two temperatures, T_1 and T_2:

$$R_1 = Ae^{B/T_1} \text{ and } R_2 = Ae^{B/T_2}.$$

Dividing yields:

$$\frac{R_1}{R_2} = e^{(B/T_1 - B/T_2)},$$

or:

$$\log R_1 - \log R_2 = B\,(1/T_1 - 1/T_2) \log e,$$

solving for B gives:

$$B = \frac{\ln R_1/R_2}{1/T_1 - 1/T_2} \qquad (2)$$

In practice B varies slightly with increasing temperature.

From Eq. (1) the temperature coefficient of an NTC may be derived:

$$\alpha = \frac{1}{R} \cdot \frac{dR}{dT} = -\frac{B}{T^2}. \qquad (3)$$

For the different materials the constant B may vary between 2000 and 5500 K:
e.g. a value of 3600 yields $\alpha = -4\%$ per K at a temperature of 300 K. For calculating the resistance of an NTC at a particular temperature, when R_{25} and B are given in the data, the graphs of Figs 2 and 3 may be used, where for different B-values R_{25}/R_T and R_T/R_{25} are plotted against the B-value with the temperature of the NTC thermistor as parameter.

V/I CHARACTERISTICS

Fig. 4 shows the relationship between current and voltage drop over the NTC thermistor when the latter is heated by this current to a temperature much higher than the ambient temperature. This characteristic was measured at a constant ambient temperature after equilibrium had been reached. For very small currents, the power consumption is too small to register a distinct rise in temperature or a decrease in resistance. In that part of the characteristic the relationship between voltage and current is therefore linear.

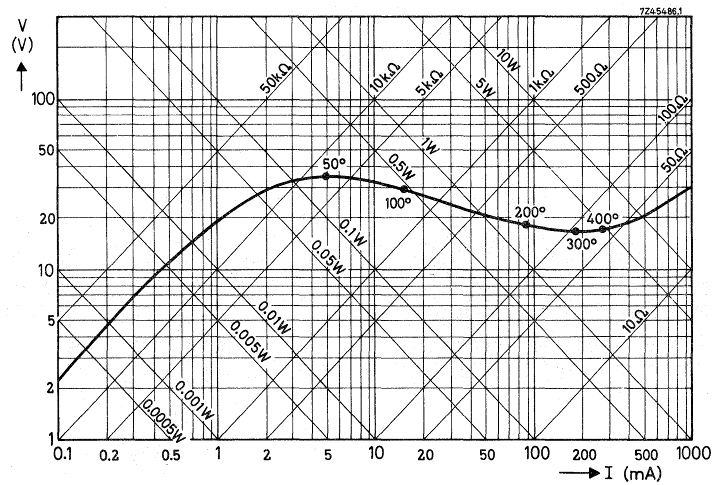


Fig. 4 Voltage versus current characteristics of an NTC thermistor.

Assuming:

(a) a constant temperature throughout the body of the thermistor;

(b) the heat transfer to be proportional to the difference in temperature between thermistor and surrounding medium (which is true for low temperatures);

(c) the resistance to be defined by eq. (1)

$$R = \frac{V}{I} = Ae^{B/T};$$

or:

$$\log_e R = \log_e A + B/T. \qquad (4)$$

In case of equilibrium

$$W = VI = \delta\,(T - T_o), \qquad (5)$$

in which T_o is the ambient temperature and δ the dissipation factor (definition on next page).

From eqs (5) and (4) follows:

$$\log_e V + \log_e I = \log_e \delta + \log_e (T - T_o), \tag{6}$$

$$\log_e V - \log_e I = \log_e A + B/T. \tag{7}$$

Combination of these two yields:

$$\log_e V = \frac{1}{2} \log_e A\,\delta + \frac{1}{2} \log_e (T - T_o) + B/2T. \tag{8}$$

This form has an extreme as a function of T if:

$$\frac{d \log_e V}{dT} = 0. \tag{9}$$

In that case

$$\frac{1}{2(T - T_o)} - \frac{B}{2T^2} = 0 \tag{10}$$

which is true only for those values of T which satisfy:

$$T^2 - BT + BT_o = 0, \tag{11}$$

$$T_{max} = \frac{1}{2}B \pm - \sqrt{\frac{1}{4}B^2 - BT_o}. \tag{12}$$

(The value with the minus sign gives the temperature corresponding to the maximum value of the voltage.) Only if $B > 4T_o$ will this maximum be present. For the practical values of B (2000 – 4000 K) the temperature T_{max} lies between 85 °C and 45 °C.

From these considerations, which are valid for static conditions only, it follows that the temperature corresponding to the maximum voltage only depends on the B-value of the material and not the actual resistance value.

THERMAL TIME CONSTANT

The thermal time constant (τ) is defined as the ratio of the heat capacity (H) of the thermistor to its dissipation factor (δ).

The heat capacity (H) is the electrical energy the thermistor needs to raise 1 K in temperature (unit J/K).

The dissipation factor (δ) is the ratio at a specified ambient temperature of a change in power dissipation in a thermistor to the resultant body temperature change (unit mW/K).

The thermal time constant is the time required for the temperature of a thermistor to change by 63,2% of the difference between its initial and final body temperatures (according to IEC 539; 85 °C and 25 °C respectively), when subjected to a step function temperature change.

H is entirely dependent on the component design. The thermal time constant depends on δ which varies for different media.

The thermal time constants mentioned in the data sheets are measured as follows, the method used depending on the application:

- by cooling in air under zero power conditions (τ_c).
- by warming or cooling, transferring the thermistor from ambient temperature of + 25 °C to a bath with a fluid of a higher or lower temperature under zero power conditions (τ_r, termed "response time" in the data sheets).
- by internal heating, subjecting the thermistor to a constant voltage or current (τ_v or τ_i).

If the thermistor has a uniform temperature during cooling, the following equation is valid for the cooling of an NTC in the time interval dt:

$$-HdT = \delta\ (T-T_o)\ dt \qquad (13)$$

in which T_o is the ambient temperature.

Eq. (13) yields: $(T-T_o) = (T_1-T_o)\ e^{-t/\tau_c}$ (14)

In a corresponding way the following equation can be derived for warming up:

$(T-T_o) = (T_1-T_o)\ (1-e^{-t/\tau_r})$.

The third case is more complicated and is based on the equation:

$P\ dt = H\ dT + \delta\ (T_1-T_o)\ dt$.

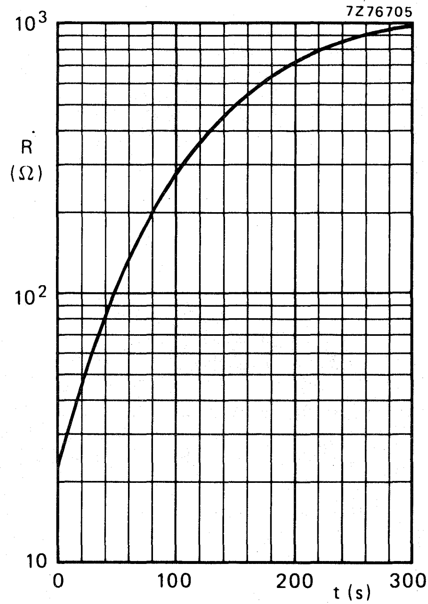


Fig. 5 Variation of resistance with time under normal cooling conditions of a rod type NTC. Ambient temperature 25 °C.

SPREAD

Resistance specified at + 25 °C (R_{25})

The R_{25} and the B-value are specified with a certain spread. The tolerance on the resistance at 25 °C is normally specified as ± 5% or ± 10%.

The B-value usually has a tolerance of ± 5%. Due to the spread in B-value, the deviation from the nominal curve at temperatures other than 25 °C can be greater than the specified tolerance at 25 °C (Fig. 6).

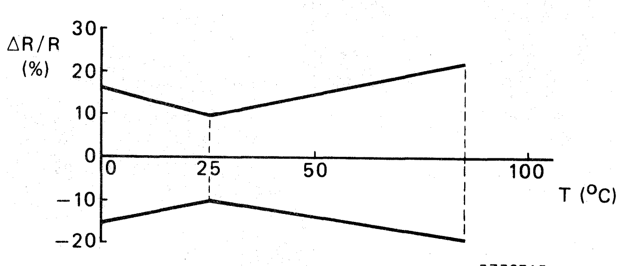


Fig. 6.

Temperature tolerances

For temperature sensors, it is appropriate to express the measuring error as a temperature tolerance rather than as $\Delta R/R$.

For one-point sensors, the temperature tolerances corresponding with the spread in R_{ref} and B-value (T_{ref} = reference temperature; usually 25 °C) can be calculated from:

$$R_T = R_{ref} \cdot e^{B\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)},$$

in which T and T_{ref} are in K.

The result of the calculation yields
at $T \approx T_{ref}$:

$$\pm \Delta T_{ref} = \frac{\Delta R_{ref}}{R_{ref}} \cdot \frac{1}{B/T^2}$$

at $T < T_{ref}$:

$$\pm \Delta T = \frac{\frac{\Delta R_{ref}}{R_{ref}} + \frac{\Delta B}{B} B\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)}{B/T^2}$$

at $T > T_{ref}$:

$$\pm \Delta T = \frac{\frac{\Delta R_{ref}}{R_{ref}} + \frac{\Delta B}{B} B\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)}{B/T^2}$$

For a practical case, the maximum error in K as a function of the temperature to be measured is expressed in Fig. 7.

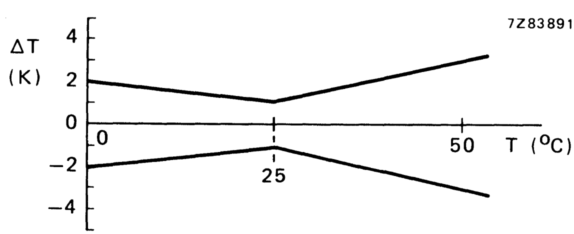


Fig. 7.

Resistance specified at more than one temperature (2 or 3-point sensors)

Thermistors which are specified at 2 or 3 points of their R/T characteristic are more accurate. They have a closer tolerance and the spread in B-value has less influence because it is included in the tolerance at the specified points.

The tolerances in the reference points can be expressed either as a temperature deviation for the reference resistance or as a resistance tolerance at the reference temperature. This have no influence on the resulting measuring error which is minimum in the temperature region between the reference points, as illustrated in Fig. 8.

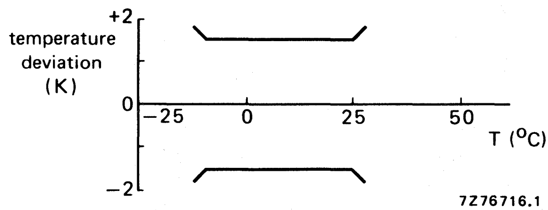


Fig. 8.

From Figs 7 and 8 it is obvious that 2 or 3-point sensors are particularly suited for applications with the following characteristics:

– temperature measurement over a certain temperature range
– high accuracy
– no further calibration for sensor tolerances in the electrical circuitry.

HOW TO MEASURE NTC THERMISTORS

The published R_T values are measured at the temperature T.

The published B-value at 25 °C is the result of a measurement at 25 °C and one at 85 °C. So, please, use these two temperatures for checking.

The following general precautions have to be taken when measuring NTC thermistors:

- Never measure thermistors in air as this is quite inaccurate and gives deviations of 1 or 2 K. For measurement at room temperature or below, use petrol or some other non-conductive and non-agressive fluid. For higher temperatures use oil, preferably silicon oil.
- Use a thermostat with an accuracy of at least 0,1 °C. Even if the liquid is well stirred, there is still a temperature gradient in the fluid. So measure the temperature as close to the NTC as possible.
- After placing the NTC in the thermostat wait until temperature equilibrium between the NTC and the fluid is obtained. For some types this may take more than 1 minute.
- Keep the measuring voltage as low as possible otherwise the NTC will be heated by the measuring current. Miniature NTC thermistors are especially sensitive in this respect. Measuring voltages of less than 0,5 V are recommended.
- For high temperature measurements it is recommended that stem correction be applied to the thermometer reading.

CHOICE OF TYPE

When selecting an NTC thermistor the following main characteristics should be considered:

- Resistance value(s) and temperature coefficient.
- Accuracy of resistance value(s).
- Power to be dissipated
  (a) without perceptible change in resistance value due to self heating
  (b) with maximum change in resistance value.
- Permissible temperature range.
- Thermal time constant, if applicable.
- Form best suited to the purpose:
  basic forms are rod, disc and bead.
- Protection against undesired external influences, if necessary.

When it is impossible to find an NTC thermistor to fulfil all requirements, it is often more economical to adapt the values of other circuit components to the value of a series-manufactured NTC. Sometimes, a standard NTC can be used with simple parallel and series resistors where otherwise a special type would have been necessary.

If no suitable combination can be found, the development of a special type can be considered. In this case a specification of the requirements is necessary. A description of the circuit in which the NTC has to be used is most useful.

DEVIATING CHARACTERISTICS

The following example explains the resistance values resulting from combinations of NTCs with normal resistors.

Suppose an NTC must have a resistance of 50 Ω at 30 °C and 10 Ω at 100 °C. A standard type having this characteristic is not included in our programme. The problem may, however, be solved by using a standard NTC and two fixed resistors. If an NTC disc with a cold resistance of 130 Ω is mounted in a series and parallel arrangement with two fixed resistors of 6 Ω and 95 Ω as illustrated in Fig. 9, the resistance of the combination at 30 °C and at 100 °C will meet the requirements. Figure 10 shows the new resistance versus temperature graph, together with that of the NTC thermistor. It should be remembered that the temperature coefficient of the combination will always be lower than that of the NTC thermistor alone. This is clearly illustrated by Fig. 11, where the change in the resistance/temperature graph is shown for different values of series and parallel resistors.

REMARKS ON THE USE OF NTC THERMISTORS

Do not use unprotected thermistors in conducting fluids or aggressive and reducing gases which may cause a change in thermistor characteristics.

For temperature measurements do not use too high a voltage on the NTC thermistor as self-heating may cause incorrect readings. The dissipation constant indicates the maximum permissible measuring power.

Choice of type

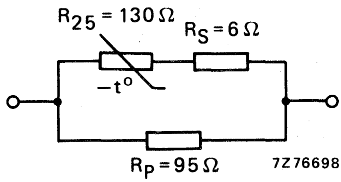


Fig. 9 NTC thermistor/resistor combination to change the R/T characteristic.

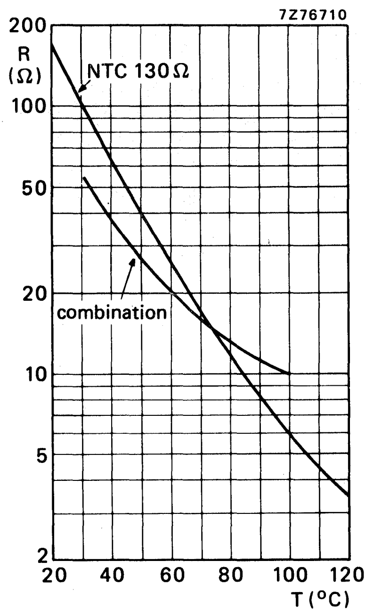


Fig. 10 Resistance as a function of temperature for the circuit of Fig. 7.

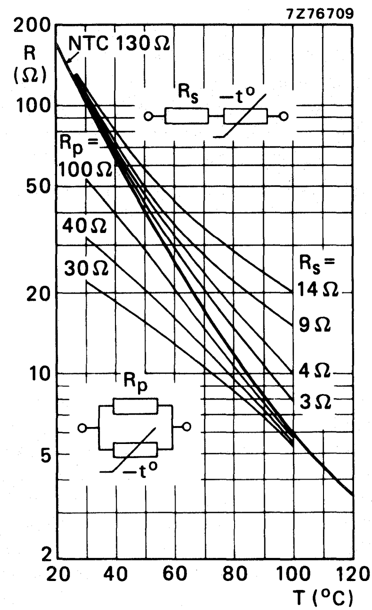


Fig. 11 Resistance as a function of temperature with the values of series and parallel resistors as parameters.

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

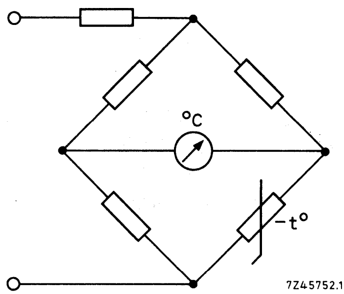
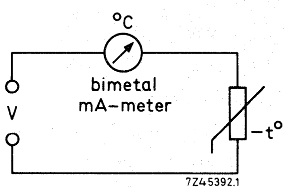


Fig. 12 Temperature measurement in industrial and medical thermometers.



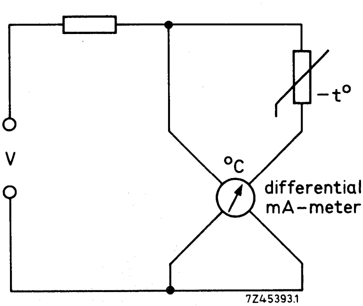


Fig. 13
Temperature measurement in cars.
Cooling water measurements with bimetal or differential milliammeters.

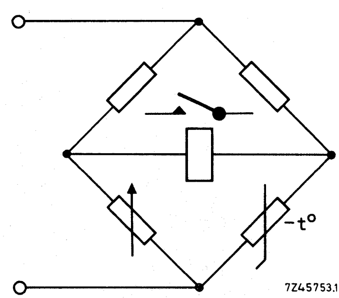


Fig. 14
Temperature control with a bridge incorporating an NTC thermistor and a relay or a static switching device.

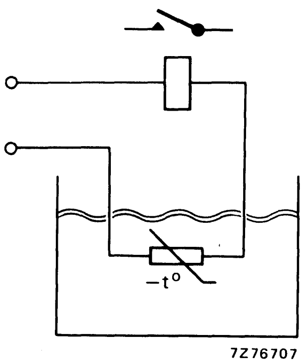


Fig. 15 Liquid level control.

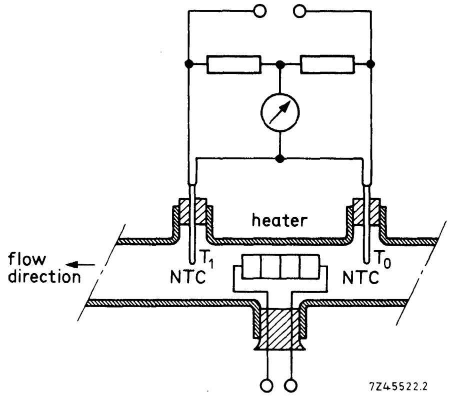
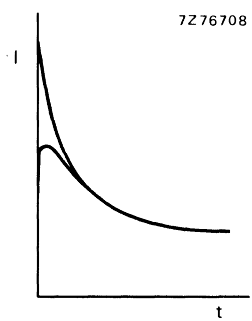


Fig. 16
Flow measurement of liquids. The temperature difference between T_1 and T_0 is a measure for the velocity of the fluid.



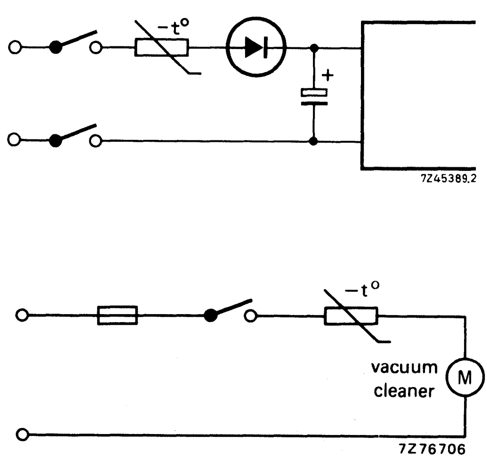
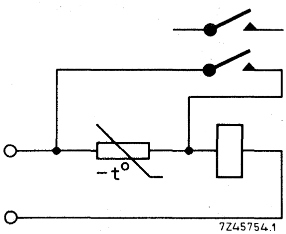


Fig. 17
Inrush current limiter, e.g. for protection of Si-diodes, fuses and switches.

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.



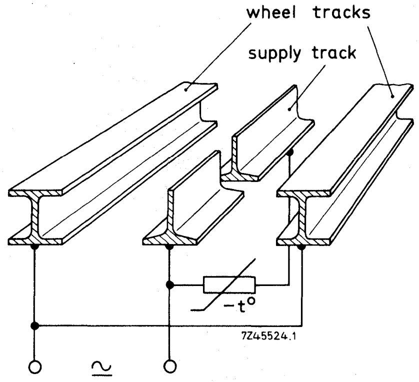


Fig. 19
Model trains. As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

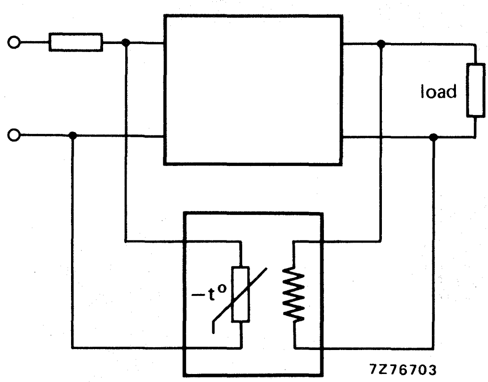


Fig. 20
Gain compensation or gain control with an indirectly heated NTC.

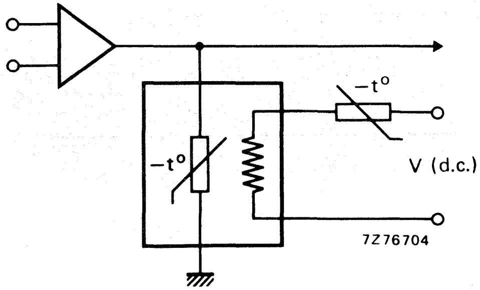


Fig. 21
Compensation for the influence of ambient temperature variations in an h.f. amplifier.

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

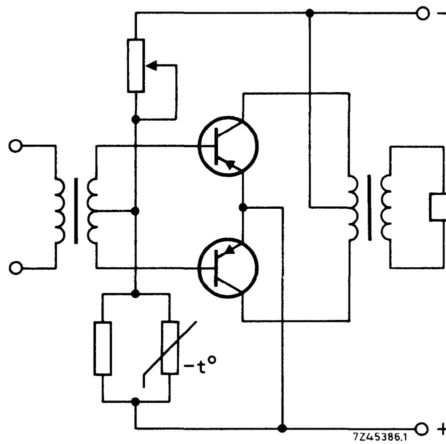


Fig. 23
Transformerless audio output stage with temperature compensation.

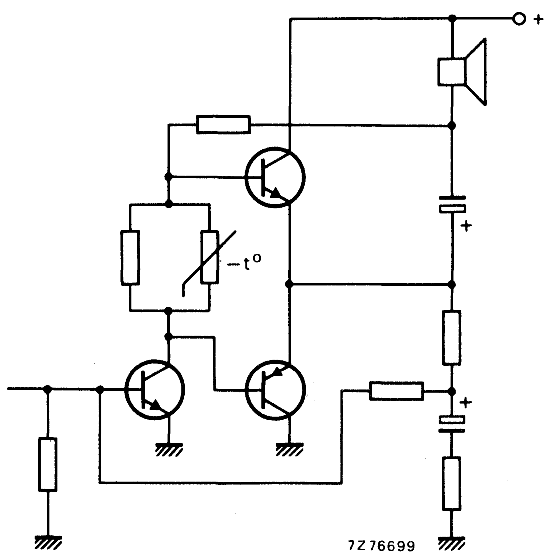


Fig. 24
Stabilization with temperature of an a.g.c. amplifier in a television set.

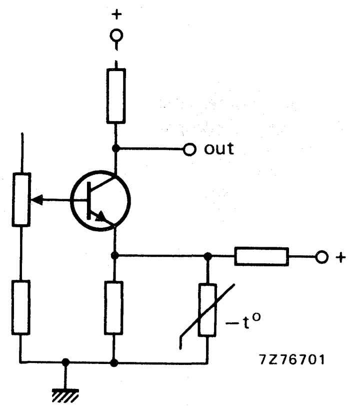
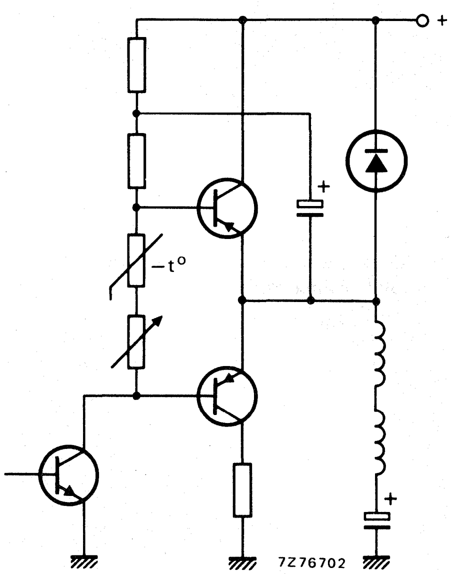


Fig. 25
Compensation of drift in field deflection coils. The influence of the positive temperature coefficient of the copper windings is compensated by means of an NTC thermistor.



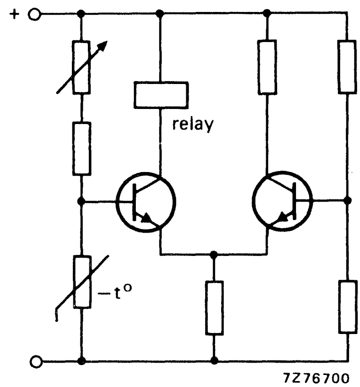


Fig. 26 Simple thermostat.

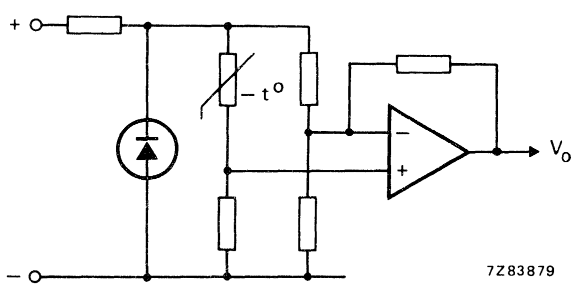
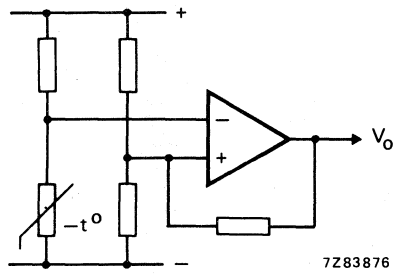


Fig. 27 Temperature sensing bridge with amplifier. The op-amp acts as difference amplifier. The sensitivity can be very high.

Fig. 28 Basic temperature sensing configuration. The operational amplifier, e.g. type NE532, acts as a Schmitt trigger. The transfer characteristic is given in Fig. 29.



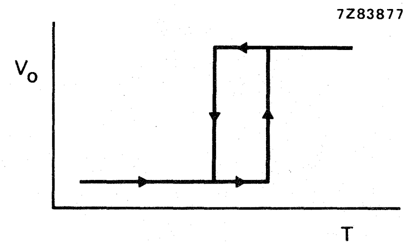
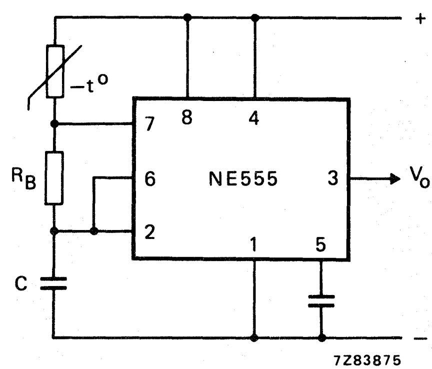


Fig. 29.

Fig. 30 Temperature controlled oscillator. This is a simple interface circuit for digital and microcomputer-controlled systems. The frequency of the output pulses is proportional to the temperature of the NTC thermistor. See Fig. 31.

$$f = \frac{1{,}49}{(R_{NTC} + 2R_B)\,C}$$



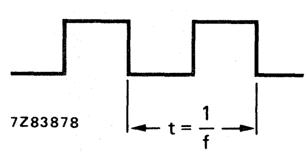


Fig. 31.

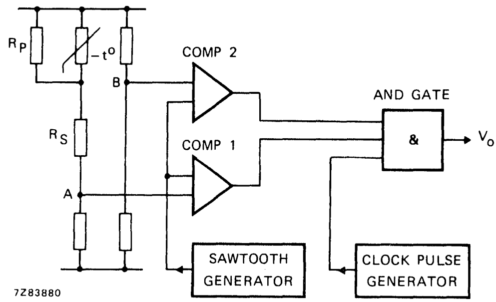


Fig. 32 Temperature sensing bridge with 0 °C offset and analogue to digital conversion. Due to R_p and R_s the voltage at point A varies linearly with the temperature of the NTC thermistor. The voltage at point B is equal to the voltage at point A when the temperature of the NTC thermistor is 0 °C. Both voltages are fed to the comparator circuit. See also Fig. 33.

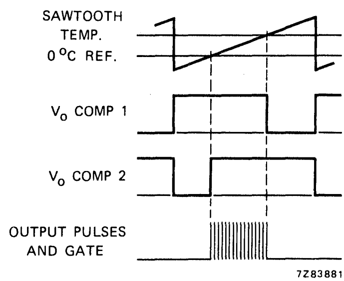
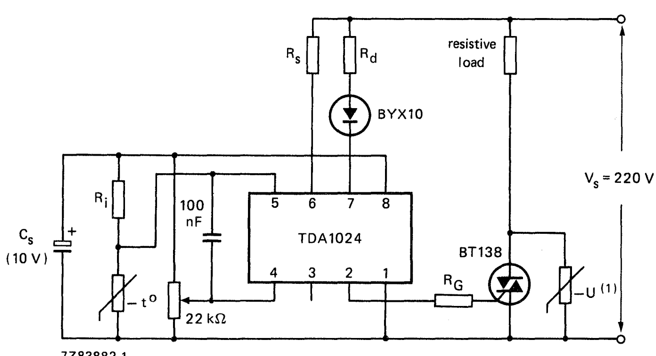


Fig. 33.



(1) spike suppressor (zinc-oxide VDR, type 2322 593 62562)

Fig. 34 Thermostat for room temperature control with a 2-point NTC thermistor as the sensing element. The TDA1024 triggers the triac during the zero crossings of the mains voltage only when the voltage across the NTC thermistor is higher than the voltage at the slider of the 22 kΩ potentiometer. (For complete information see our Technical Informations 010 and 025).

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

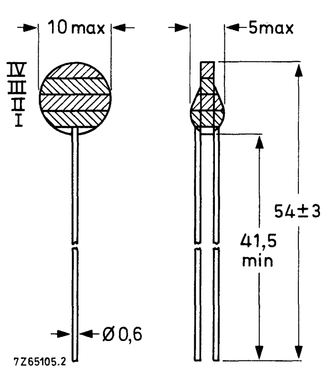


Fig. 1.

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

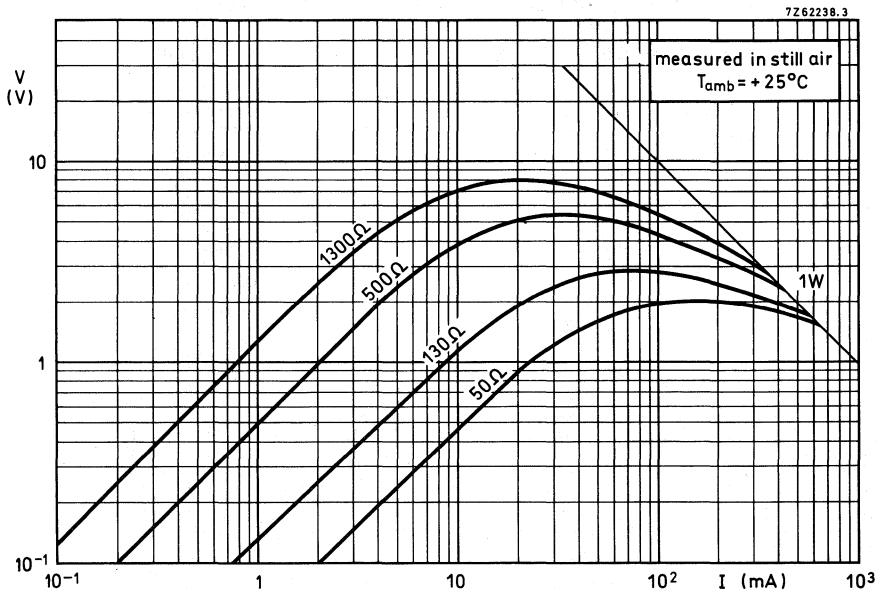
Maximum dissipation *	1 W
Dissipation factor *	10 mW/K approx.
Thermal time constant *	60 s approx.
Heat capacity *	0,6 J/K approx.
Operating temperature	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

See further Table 1.

* 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



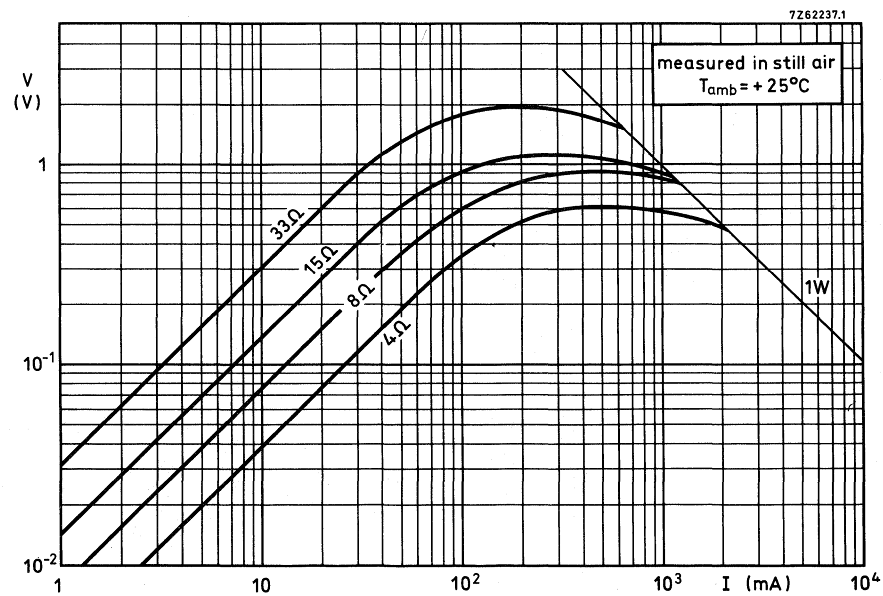


Fig. 2a and b Typical voltage/current characteristics.

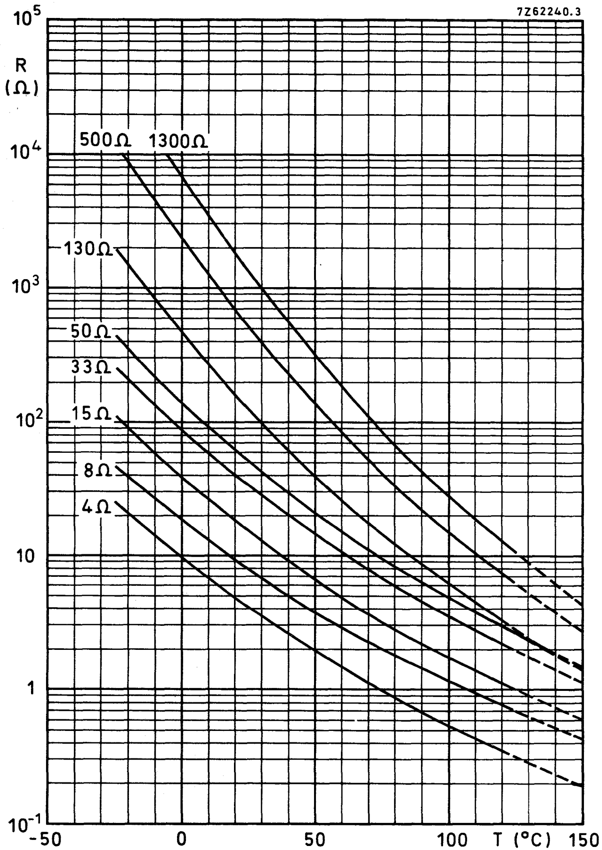


Fig. 3 Typical resistance/temperature characteristics.

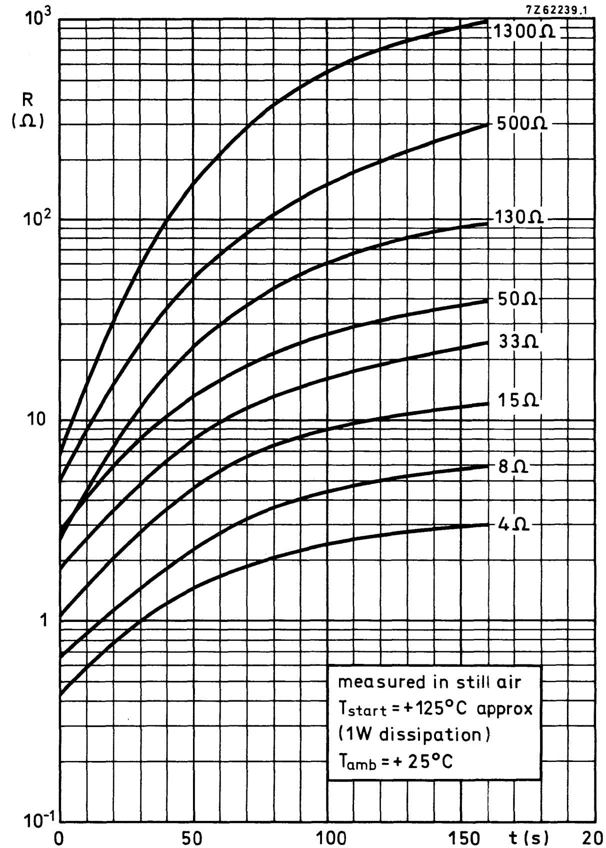


Fig. 4 Typical resistance/time (cooling) characteristics.

NTC THERMISTORS

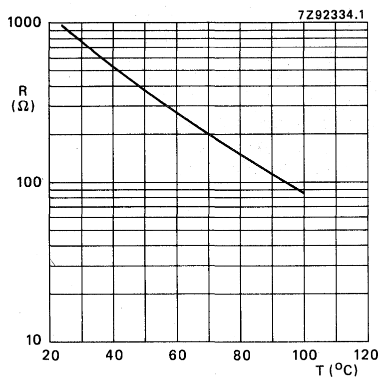
for motor cars

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

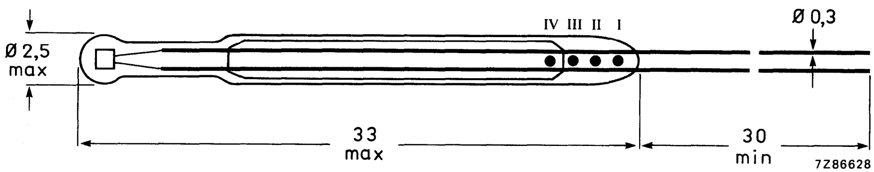


Fig. 1 Maximum bow in the centre of the glass envelope is 1 mm.

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.

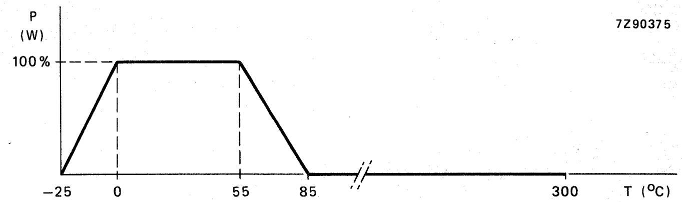


Fig. 2 Derating curve.

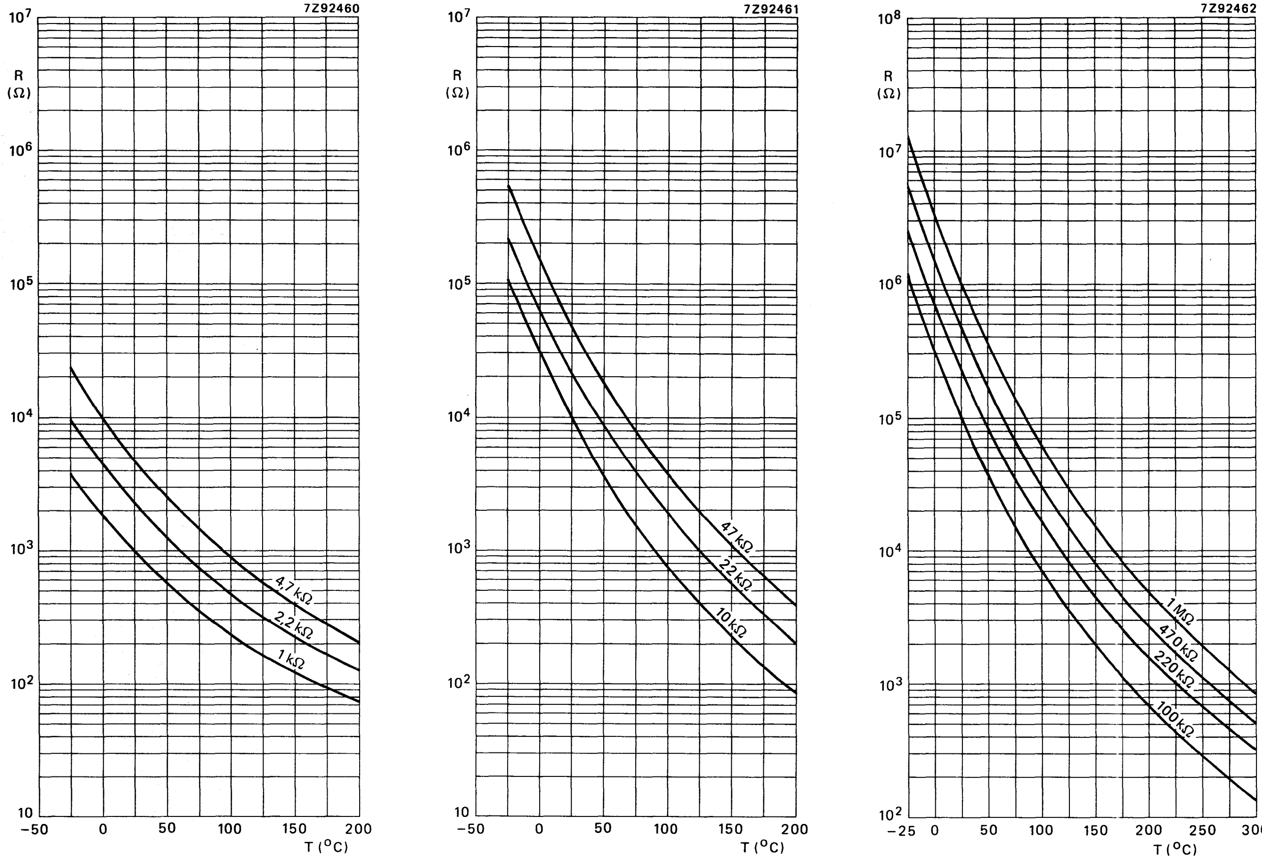
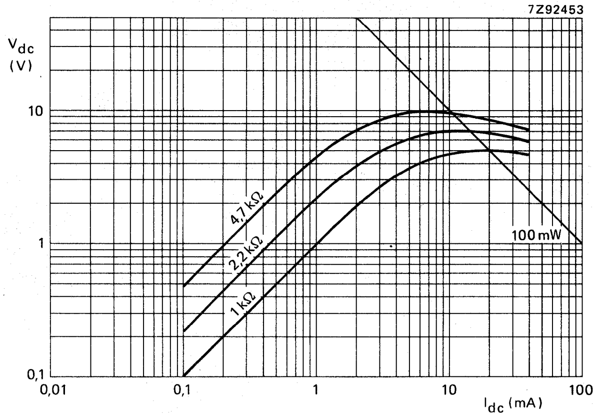
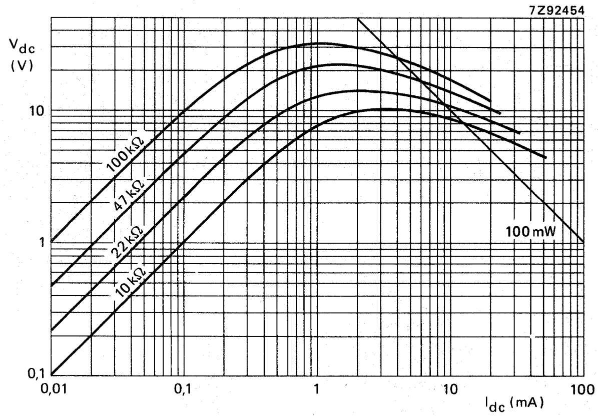


Fig. 3 Typical resistance/temperature characteristics.





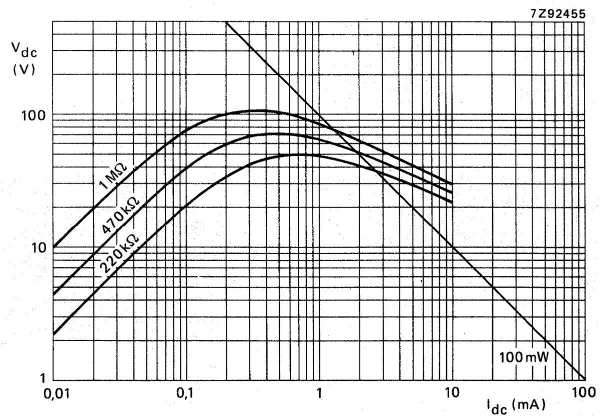


Fig. 4 Typical voltage/current characteristics. Measured in still air at 25 °C.

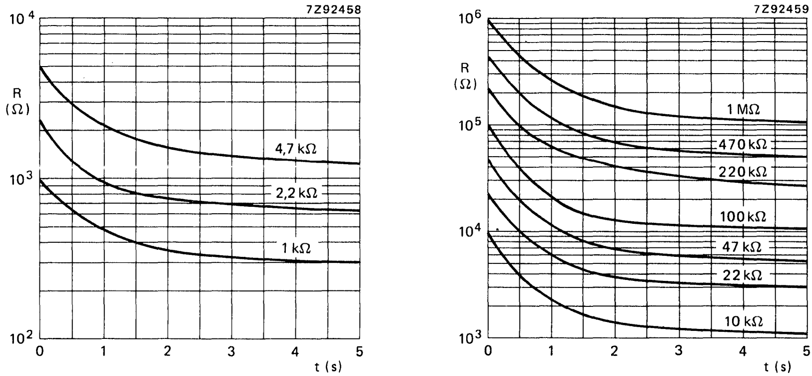


Fig. 5 Typical resistance/response characteristics.
Temperature step from air at 25 °C to oil at 85 °C.

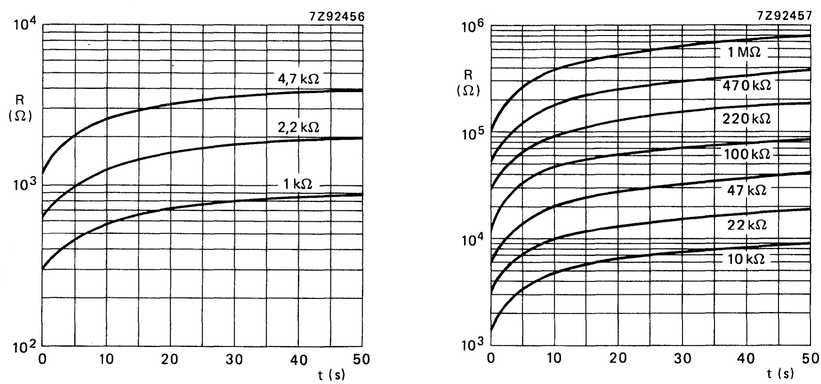


Fig. 6 Typical resistance/cooling time characteristics.
Measured in still air at 25 °C. T_{start} = 85 °C.