PHILIPS

Data handbook

Electronic components and materials

Components and materials

Part 11 May 1982

Voltage dependent resistors

Light dependent resistors

Negative temperature coefficient thermistors

Positive temperature coefficient thermistors

COMPONENTS AND MATERIALS

PART 11 — MAY 1982

NON-LINEAR RESISTORS

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, subassemblies and materials; it is made up of four series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

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ELECTRON TUBES (BLUE SERIES)

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T1 **Tubes for r.f. heating**

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T3 **Klystrons, travelling-wave tubes, microwave diodes**

ET3 **Special Quality tubes, miscellaneous devices** (will not be reprinted)

T4 **Magnetrons**

T5 **Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications

T6 **Geiger-Müller tubes**

T7 **Gas-filled tubes**
Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories

T8 **Picture tubes and components**
Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display

T9 **Photo and electron multipliers**
Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates

T10 **Camera tubes and accessories, image intensifiers**

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* Will become available in the course of 1982.

SEMICONDUCTORS (RED SERIES)

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S1 Diodes
Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes($< 1,5$ W), voltage reference diodes, tuner diodes, rectifier diodes

S2 Power diodes, thyristors, triacs
Rectifier diodes, voltage regulator diodes ($> 1,5$ W), rectifier stacks, thyristors, triacs

S3 Small-signal transistors

S4 Low-frequency power transistors and hybrid IC modules

S5 Field-effect transistors

S6 R.F. power transistors and modules

S7 Microminiature semiconductors for hybrid circuits

S8 Devices for optoelectronics
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.

S9 Taken into handbook T11 of the blue series

S10 Wideband transistors and wideband hybrid IC modules

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The purple series of data handbooks is comprised of the following parts:

IC1	**Bipolar ICs for radio and audio equipment**
IC2	**Bipolar ICs for video equipment**
IC3*	**Digital ICs for radio, audio and video equipment**
IC4	**Digital integrated circuits** LOCMOS HE4000B family
IC5	**Digital integrated circuits – ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs
IC6*	**Professional analogue integrated circuits**
IC7	**Signetics bipolar memories**
IC8	**Signetics analogue circuits**
IC9*	**Signetics TTL circuits**

* These handbooks will be available in the course of 1982.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks is comprised of the following parts:

C1 **Assemblies for industrial use**
PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs, peripheral devices

C2 **FM tuners, television tuners, video modulators, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Electric motors and accessories**
Permanent magnet synchronous motors, stepping motors, direct current motors

CM7a **Assemblies** (will not be reprinted)
Circuit blocks 40-series and CSA70(L), counter modules 50-series, input/output devices

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**
Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Variable resistors and test switches**

C13 **Fixed resistors**

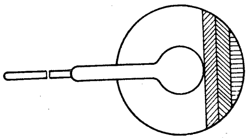
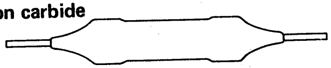
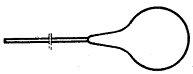
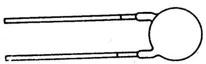
C14 **Electrolytic and solid capacitors**

C15 **Film capacitors, ceramic capacitors, variable capacitors**

C16 **Piezoelectric ceramics, permanent magnet materials**

VOLTAGE DEPENDENT RESISTORS (VDR) A

SURVEY

type	voltage V	current mA	dissipation W	β-value	catalogue number
DISC, silicon carbide 	8 to 330	100 to 1	0,8	0,14 to 0,40	2322 552 0....
	8 to 330	100 to 1	1	0,14 to 0,40	2322 553 0....
	8 to 330	100 to 1	2	0,14 to 0,40	2322 554 0....
	8 to 330	100 to 1	3	0,14 to 0,40	2322 555 0....
ROD, silicon carbide 	56 to 1300	1 to 10	0,8	0,16 to 0,36	2322 564 02... 2322 564 90...
SMALL DISC					
silicon carbide 	6 to 18	1	0,1	max. 0,20 to 0,28	2322 565 9000.
titanium oxide	2,7 to 68	1	0,25		2322 581 03...
zinc oxide 	60 to 460		0,1 0,3		2322 592 3.... 2322 592 6.... 2322 593 3.... 2322 593 6.... 2322 594 6.... 2322 595 6....

INTRODUCTION

V(oltage) D(ependent) R(esistors), also called "Varistors", show a high degree of non-linearity between their resistance value and the applied voltage. They are made of non-homogeneous material giving a rectifying action at the contact of two particles.

Various materials are used to cause the voltage depending resistance. The principal ones are:

- silicon carbide;
- zinc oxide;
- titanium oxide.

The electrical characteristic of the conglomeration is determined by a large number of crystal contacts which form a complicated network of series and parallel rectifying contacts.

These resistors have found a diversity of applications in the different sectors of electronics. They offer a cheap and reliable solution for protection of electronic circuits, semiconductor components, collectors of motors, relay contacts, etc. against over-voltages and their consequences.

MANUFACTURING PROCESS

Crystals of silicon carbide, or of metal oxides, with the right electrical and dimensional properties are pressed together with a ceramic binder to the shape of discs or rods. After a drying period the VDRs are sintered at a high temperature. Firing time, temperature and gaseous atmosphere have an important influence on the electrical characteristics. The contacts are metallized with silver or copper enabling good electrical contact. After leads have been soldered to the contacts the VDRs are lacquered and coded. Some types, made for clamp contacts or other mounting methods, are delivered unlacquered and without leads.

During and after the manufacturing process the electrical properties are controlled not only to ensure that the VDRs are within the specification but also to control stability and reliability of the resistors.

ELECTRICAL PROPERTIES

DIRECT CURRENT

The relation between voltage and current of a VDR can be approximated by:

$$V = C.I^{\beta} \quad (1)$$

where V is the voltage in volts, I the current in amperes and C and β are constants. This equation is illustrated in Fig. 1. In principle the same characteristic is plotted for a specific type on a double logarithmic scale in Fig. 2. For not too small values of current this relation is a straight line which follows directly from the equation $\log V = \log C + \beta \log I$. In this case β is the directional coefficient of the straight line.

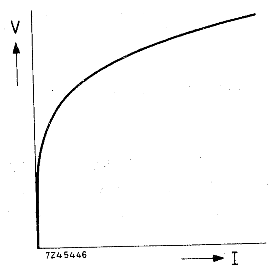


Fig. 1 Shape of the voltage/current characteristic of a VDR when plotted on a linear scale.

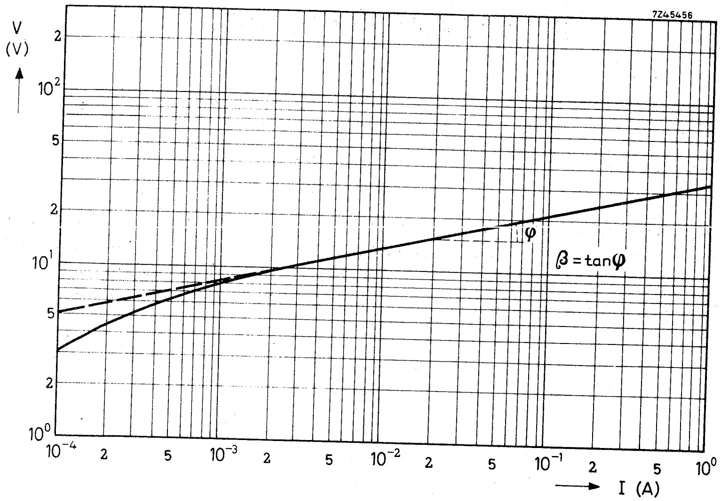


Fig. 2 Voltage/current characteristic of a VDR plotted on a logarithmic scale.

In order to determine the exact values of the constants C and β it is necessary to measure three points of the characteristic. Only when these are on a straight line when plotted on a double logarithmic scale, is extrapolation permitted (only to higher values). Equation (1) may also be written:

$$I = \left(\frac{V}{C}\right)^{\alpha} \qquad (2)$$

in which:

$$\alpha = 1/\beta \qquad (3a)$$

and

$$K = \frac{1}{C^{1/\beta}} = \frac{1}{C^{\alpha}}. \qquad (3b)$$

The VDRs do not have a polar effect; this means that when the voltage is changed from positive to negative, the current changes its direction, but retains its value. Strictly speaking, Eqs (1) and (2) are valid only when the absolute values are taken for I and V. In a.c. calculations this may be very important. For practical design, reference is made to the voltage/current characteristics given in the data sheets of the relevant VDR types.

Practical values and specification

The C and β-values of a VDR depend on the composition of the material and on the method used in the processing; furthermore, the C-value depends on the shape and the dimensions of the VDR. → Practical β-values are for SiC: β = 0,15 to 0,40, for ZnO: β = 0,02 to 0,035 and for TiO_2: β = 0,2 to 0,28. It is inherent to the material properties that the β-value of a VDR with a low C-value will always be higher than that of a VDR with a high C-value. Practical C-values range from 14 to a few thousand. As the method of fabrication compels a minimum thickness and, as will be seen further, enlarging of the surface area gives little change in the C-value, the latter has for practical reasons a limited lowest value.

According to Eq. (1) it is possible to specify the electrical characteristics of a VDR resistor by giving its C and β-values. The advantage of this specification is that only two parameters are used. The disadvantage is, however, that due to the inevitable tolerances on the β-values, the spread in voltages at low currents (in the working area) becomes very large. It is for this reason that the method of specifying by the C-value defined at 1 A is abandoned and we now specify the voltage across the VDR at currents which lie in the working area (1, 10 or 100 mA instead of 1 A). In this way it is possible to supply VDRs which have much closer tolerances in the area where they are used, see Fig. 10.

VDRs in series

For each VDR we can write the equation:

$$V = CI^{\beta}. \tag{1}$$

When n equal elements are connected in series and a voltage of n times the original voltage is applied, the current will be the same as for V volts over one VDR. Consequently we may write for a series circuit of n VDRs:

$$nV = C'.I^{\beta}. \tag{4}$$

Froms Eqs (1) and (4) it is evident that,

$$C' = nC, \tag{5}$$

which means that the C-value of a VDR can be increased ad libitum by series connection.

VDRs in parallel

For one VDR again we have:

$$V = CI^{\beta}. \tag{1}$$

Now when n of these VDRs are connected in parallel and the same voltage V is applied, the current in each VDR will still be the same. The total current in the circuit will be nI. This gives the following equation:

$$V = C''(nI)^{\beta}. \tag{6}$$

From Eqs (1) and (6) it follows:

$$C'' = \frac{C}{n^{\beta}}. \tag{7}$$

As VDRs have a β-value from 0,02 to 0,40, it is clear that the C-value will decrease very little by connecting two or more elements in parallel. When, e.g. $\beta = 0{,}20$, 32 VDRs are needed for a 50% reduction of the C-value. It is important that in parallel circuits all VDRs have about the same β and C-values, otherwise the current division will very much depend on the voltage across the circuit.

Note: On no occasion may a VDR be connected in parallel with the aim of obtaining higher power dissipation.

Resistance value

When defining R as usual as the quotient of voltage and current, we find:

$$R = \frac{V}{I} = \frac{CI^{\beta}}{I} = \frac{C}{I^{1-\beta}} \qquad (8)$$

or when starting from the form $I = (\frac{V}{C})^{\alpha}$:

$$R = \frac{V}{I} = \frac{V}{\frac{V^{\alpha}}{C^{\alpha}}} = \frac{C^{\alpha}}{V^{\alpha-1}} \qquad (9)$$

From these equations it is once more evident that the resistance value is not a constant one, but is very much dependent on the values of voltage and current.

Dissipated power

The power dissipated in a VDR is equal to the product of voltage and current, so it may be written:

$$W = I.V = (\frac{V}{C})^{\alpha}.\, V = \frac{V^{\alpha+1}}{C^{\alpha}} \qquad (10)$$

When the coefficient $\alpha = 5$, the power dissipated by the VDR is proportional to the 6th power of the voltage. A voltage increase of only 12% will, in this case, double the dissipated power. Consequently it is very important that the applied voltage does not rise above a certain maximum value, as otherwise the permissible rating will be exceeded.

This is even more cogent, as the VDRs have a negative temperature coefficient, which means that at higher dissipation (and accordingly higher temperature) the resistance value will decrease and the dissipated power will increase still more.

Temperature coefficient

In the foregoing formulae no temperature effects have been taken into account. These, however, may not always be neglected, as the C-value has an appreciable negative temperature coefficient. The β-value is practically independent of the temperature. With good approximation it may be written:

$$C_t = C_0\,(1 + at), \qquad (11)$$

in which:

C_t = C-value of the VDR at t °C;

C_0 = C-value of the VDR at 0 °C;

a = temperature coefficient.

For different materials the value of a lies between −0,0010 and −0,0018. Thus, for circuits where the current is constant, the temperature coefficient on voltage lies between −0,10 and −0,18% per degree K.

For circuits where the voltage is constant the temperature coefficient on current lies between + 0,4 and + 0,8% per degree K, depending on the β-value.

High frequency alternating current

For low frequencies the small capacitance of the VDR does not affect the voltage dependency of the resistance. For high frequencies, however, this parallel capacitance may not be neglected. For low voltages and currents they may even determine the impedance of the VDR. At high voltages, the influence of the capacitance is less serious; because in that case the resistance over which this capacitance is shunted has decreased. In general the effect of the capacitance in h.f. circuits will be an apparent increase of β. Furthermore the voltage/current graph on a logarithmic scale will no longer be a straight line.

A number of curves demonstrating this effect are given in Fig. 8.

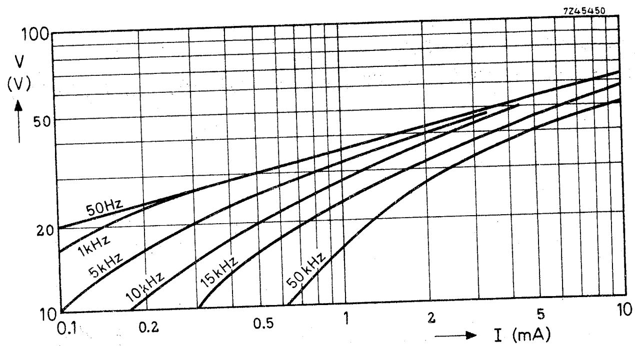


Fig. 8 Voltage/current relation for different frequencies.

PERMISSIBLE DISSIPATION

The temperature which a VDR will reach is determined by the dissipated power, the heat conductivity of the material, the contact with, and the nature of, the surrounding medium and by the ambient temperature. As already explained the dissipated power will increase rapidly with increasing voltage.

The cooling per degree Celcius, though increasing slightly with temperature, depends mainly on the total surface area of the VDR.

For most VDR types the maximum permissible body temperature is 125 ^{o}C.

ZINC-OXIDE VOLTAGE DEPENDENT RESISTORS

Unlike SiC types, the ZnO VDRs are mainly intended for applications requiring intermittent power dissipation, i.e. transient suppression and contact arc prevention. In their transient suppression role, the symmetrical mode of operation allows them to be connected directly across a.c. power lines carrying r.m.s. voltages of 60 to 460 V (currently available types). They are capable of withstanding voltage or current pulses with a high peak energy level. A typical β for this type of VDR is 0,03. This means that, if the current through the VDR increases by a factor of 10 within the straight-line portion of the characteristic, the voltage across it increases by a factor of 1,07

A typical V/I characteristic for one of these VDRs is shown in Fig. 9. The upward turn of the characteristic (decreasing non-linearity) is due to the increasing influence of the linear series resistance of the component as its non-linear resistance falls to very low values at extreme currents. A good approximation of the relationship between the voltage and the current in the curved portion of the characteristics is given by the expression:

$$V = CI^{\beta} + IR_s,$$

where R_s is the series resistance of the VDR.

See further the data sheets of the VDR series 2322 592 6...., 2322 593 6...., 2322 594 6.... and 2322 595 6.... .

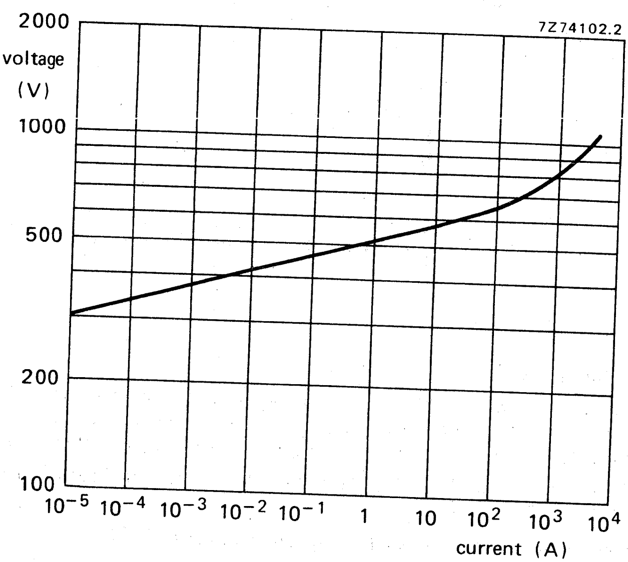


Fig. 9 Typical V/I characteristic of ZnO VDR 2322 595 62512 for 220 V mains supply.

Normal operating conditions of the ZnO VDR

Owing to the extreme nonlinearity of the voltage/current characteristic of ZnO VDRs, and the necessity to allow a margin for the extra dissipation during a transient, ensure that the maximum voltage applied across the VDR during normal operation never attains such a value that the specified average dissipation limit of the VDR is approached. This will never be a problem if the VDR is selected according to the figures for max. r.m.s. voltage in the data sheet. The peak value of the sinusoidal voltage applied to the VDR must always be less than the minimum voltage specified at 1 mA. If the applied voltage is other than sinusoidal, the VDR should be selected on the basis of the specified maximum peak working voltage.

HOW TO MEASURE VOLTAGE DEPENDENT RESISTORS

The following points have to be considered when measuring VDRs.

1. Use only d.c. voltage.
2. Keep the measuring time as short as possible. Self-heating effects may influence the measurements due to the negative temperature coefficient of the VDRs.
3. When the VDRs are specified at a voltage and current which is above the maximum dissipation, pulses should be used. For instance all 2322 564 VDR types which are used in television circuits are measured under pulse-conditions. These types are measured with a rectangular current pulse having a duration of 10 ms.
4. The β-value measurement needs some explanation. As mentioned on page 5 the β-value is not always constant but depends on the voltage and current. The β-values of our discs are measured between 0,3 I and 3 I, those of our rods between I and 10 I (unless otherwise specified), where I is the current at which the VDR is specified. For example:

$$\beta = \log \frac{V_2}{V_1}; \text{ with } V_2 = \text{voltage at 3 I}, \quad V_1 = \text{voltage at 0,3 I}.$$

TOLERANCES

Standard VDRs are specified with a certain tolerance on voltage and a spread on β-value. It can be seen in Fig. 10 that due to the spread in β-value the tolerance on voltage may increase at currents other than the specified current at which the VDR is measured.

For some applications, where tolerances have to be kept as low as possible, the VDRs are measured at a current or voltage which lies near to its working point in the circuit, e.g. the standard rod types for television, series 2322 564 02 are measured at 10 mA.

For other applications, especially spark suppression, it is often important to specify the VDR at two points: a point at low current or low voltage and a point at high current or high voltage.

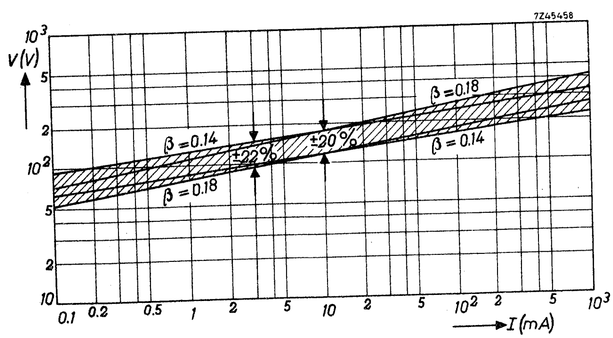


Fig. 10 Spread of voltage/current characteristic due to β-tolerance.

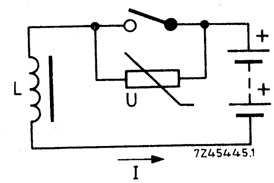
APPLICATIONS

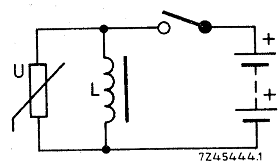
Some of the most important application principles are given in the following pages. Well known television applications are the VDR used as a rectifier of non-symmetrical pulses, and for stabilization against supply voltage variations and aging of components. The VDR is also used in TV sets across the primary of the frame output transformer for damping oscillations, while in other circuits VDRs fulfil the functions of voltage stabilization devices. Outside the entertainment field we find VDRs used in telecommunications as relay contact protectors. A special range of VDRs has been developed for this purpose. Similar application can be found in small battery motors where the VDR increases the commutator life considerably. There are many more uses for VDRs and the following selection is by no means complete.

Contact-protection and spark suppression

Two principal circuits are used. As soon as the contacts open, the energy stored in the inductance ($\frac{1}{2}LI^2$) is dissipated by the VDR, limiting the voltage across the contacts to a safe value.

Zinc oxide VDRs (2322 592/593/594/595 series) are designed especially for the suppression of voltage transients.

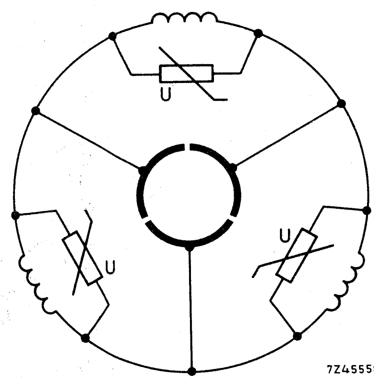




Protection of small battery motors

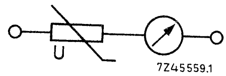
Sparking brush contacts limit the commutator life and give rise to interference with nearby radio or audio circuits. A small VDR in parallel to the rotor windings prevents the sparking and so increases the commutator life considerably.

Multi-segment discs (3 to 6 VDR sections per disc) are available for incorporation into the commutator construction.



VDR for adapting meter sensitivity

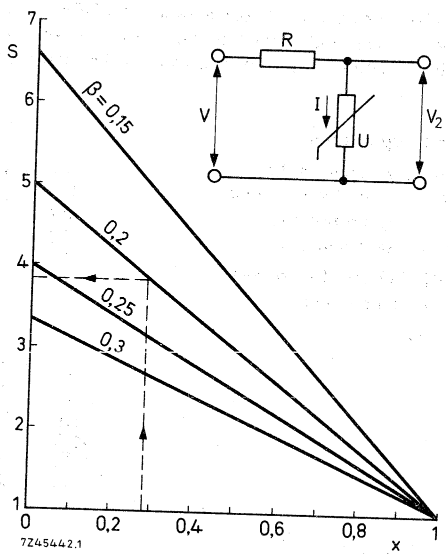
A VDR in series with a voltmeter or in parallel with a milliammeter enables part of the scale to be expanded for more accurate reading of measurements.



Stabilization of a voltage without load when the supply voltage varies

It can be shown that the VDR stabilizes varying supply voltages by a factor

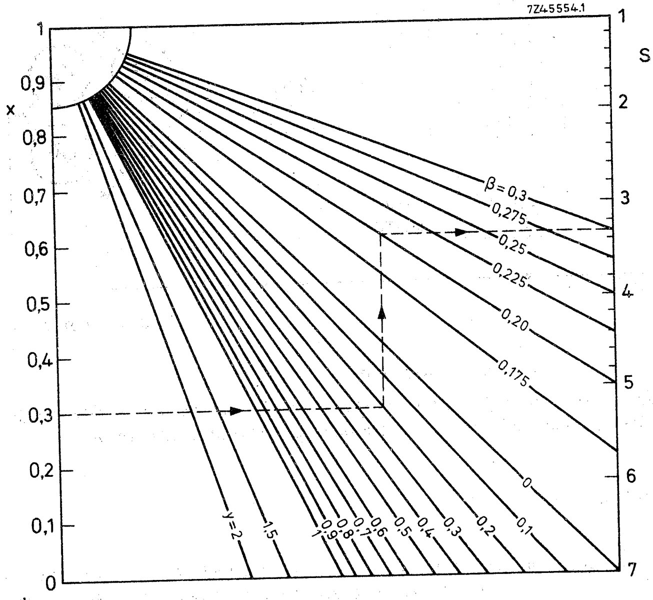
$$S = \frac{\Delta V/V}{\Delta V_2/V_2} = \frac{1}{\beta} - \frac{1-\beta}{\beta} \cdot x, \quad \text{where } x = V_2/V.$$

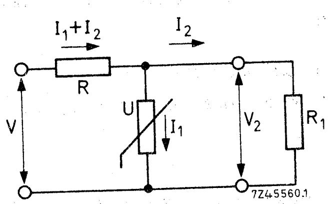


Stabilization of a voltage with load

$$S = \frac{1}{\beta} - \frac{1-\beta}{\beta} \cdot \frac{x+y}{1+y}$$ where $x = V_2/V$ and $y = I_2/I_1$.

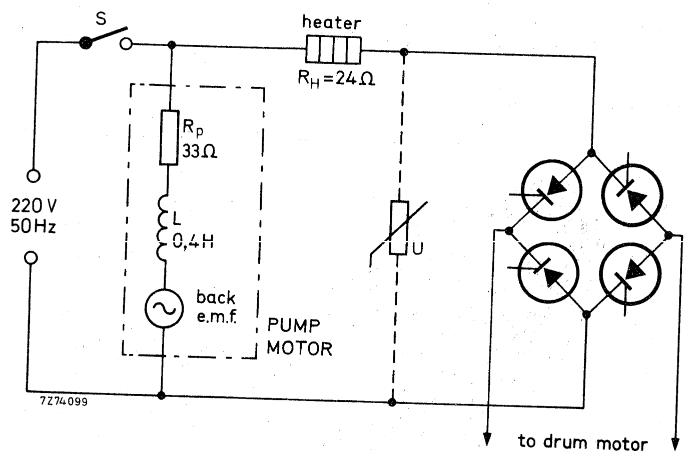
The nomogram makes S easy to find.





The silicon carbide and titanium oxide VDRs (2322 552 to 2322 555 series and 2322 581 series) are particularly suited for stabilization of d.c. voltages.

Protection of a thyristor bridge in a washing machine



Behaviour of the circuit without VDR protection

The measured peak current through the pump motor when S is closed is 1 A. The energy expended in establishing the electromagnetic field in the inductance of the motor is therefore:

$$\frac{I^2 L}{2} = \frac{0,4}{2} = 200 \text{ mJ}.$$

Without VDR protection, an initial current of 1 A will flow through the thyristor bridge when S opens, and a voltage sufficient to damage or destroy the thyristors will be developed. Arcing will occur across the opening contacts of the switch.

→ *Behaviour of the circuit with VDR 2322 593 62512*

On opening switch S, the peak voltage developed across the VDR is:

$$V = C_{max} I^{\beta} = 600 \text{ V}.$$

The thyristors in the bridge can withstand this voltage without damage.

The total energy returned to the circuit is 200 mJ. Of this 15,7 mJ are dissipated in the heater and 184,3 mJ are dissipated in the VDR. The VDR can withstand more than 10^5 transients containing this amount of energy.

VOLTAGE DEPENDENT RESISTORS

silicon carbide disc

QUICK REFERENCE DATA

D.C. voltage		
I_{nom} = 100 mA	8 to 12	V
I_{nom} = 10 mA	8 to 68	V
I_{nom} = 1 mA	56 to 330	V
β between 0,3 I_{nom} and 3 I_{nom}	0,14 to 0,40	
Maximum dissipation	0,8	W
Operating temperature range		
zero power	−25 to +125	°C
max. power	0 to + 55	°C

APPLICATION

Voltage stabilization, contact protection and spark suppression.

DESCRIPTION

A disc of silicon carbide with axial tinned copper leads. The disc is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

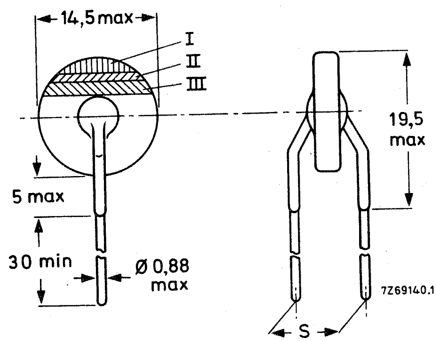


Fig. 1 S = 9 mm for types with C values up to 500. S = 10 mm for others, see table.

Marking

A three-band colour code as shown in Fig. 1. This code indicates the three figures following the zero in the last part of the catalogue number shown in Table 1. The colours are in accordance with the standard VDR resistor colour code, e.g. type 2322 552 01161 is coded brown, brown, blue (100 mA, 8 V). See Table 2.

Mass

See Table 1.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

ELECTRICAL DATA

Tolerance on voltage at I_{nom}	± 20% or ± 10%*
Maximum dissipation	0,8 W
Asymmetry	max. 2%
Operating temperature range	
zero power	−25 to +125 °C
max. power	0 to + 55 °C

See further Table 1.

PACKAGING

100 resistors in a cardboard box.

* The 10% types have an extra silver tipping.

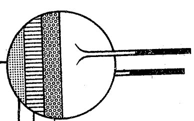
Table 1 Catalogue numbers 2322 552 0....

suffix of catalogue number 20% on V*	d.c. current I_{nom} mA	voltage at I_{nom} V	β	C approx.	mass g	S max (Fig. 1) mm
1161	100	8	0,25 to 0,40	14	1,3	9
1181	100	10	0,25 to 0,40	18	1,3	9
1201	100	12	0,25 to 0,40	21	1,3	9
2161	10	8	0,25 to 0,40	25	1,3	9
2181	10	10	0,25 to 0,40	32	1,4	9
2201	10	12	0,25 to 0,40	40	1,4	9
2221	10	15	0,25 to 0,40	48	1,4	9
2241	10	18	0,21 to 0,35	57	1,45	9
2261	10	22	0,21 to 0,35	60	1,45	9
2281	10	27	0,21 to 0,35	70	1,45	9
2301	10	33	0,18 to 0,25	85	1,45	9
2321	10	39	0,18 to 0,25	100	1,45	9
2341	10	47	0,18 to 0,25	130	1,45	9
2361	10	56	0,18 to 0,25	150	1,45	9
2381	10	68	0,18 to 0,25	180	1,45	9
3361	1	56	0,14 to 0,23	190	1,45	9
3381	1	68	0,14 to 0,23	230	1,45	9
3401	1	82	0,14 to 0,21	300	1,5	9
3421	1	100	0,14 to 0,21	350	1,6	9
3441	1	120	0,14 to 0,21	400	1,65	9
3461	1	150	0,14 to 0,21	500	1,75	9
3481	1	180	0,14 to 0,21	600	1,9	10
3501	1	220	0,14 to 0,21	750	2,15	10
3521	1	270	0,14 to 0,21	900	2,3	10
3541	1	330	0,14 to 0,21	1100	2,6	10

* For a 10% tolerance on voltage, replace last digit (1) of the catalogue number by a 2.

Table 2.

VDR standard



brown = 100 mA
red = 10 mA
orange = 1 mA

silver tipped 10% tol.

untipped 20% tol.

brown/blue	= 8 V	orange/blue	= 56 V
brown/grey	= 10 V	orange/grey	= 68 V
red/black	= 12 V	yellow/black	= 82 V
red/red	= 15 V	yellow/red	= 100 V
red/yellow	= 18 V	yellow/yellow	= 120 V
red/blue	= 22 V	yellow/blue	= 150 V
red/grey	= 27 V	yellow/grey	= 180 V
orange/black	= 33 V	green/black	= 220 V
orange/red	= 39 V	green/red	= 270 V
orange/yellow	= 47 V	green/yellow	= 330 V

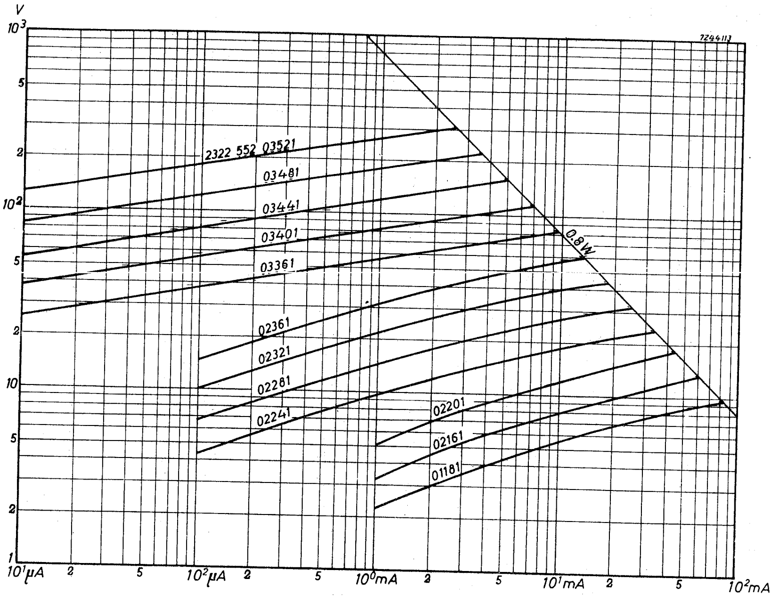


Fig. 2 Voltage/current characteristics.

VOLTAGE DEPENDENT RESISTORS

silicon carbide disc

QUICK REFERENCE DATA

D.C. voltage	
I_{nom} = 100 mA	8 to 15 V
I_{nom} = 10 mA	10 to 82 V
I_{nom} = 1 mA	68 to 330 V
β between 0,3 I_{nom} and 3 I_{nom}	0,14 to 0,40
Maximum dissipation	1 W
Operating temperature range	
zero power	–25 to +125 °C
max. power	0 to + 55 °C

APPLICATION

Voltage stabilization, contact protection and spark suppression.

DESCRIPTION

A disc of silicon carbide with axial tinned copper leads. The disc is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

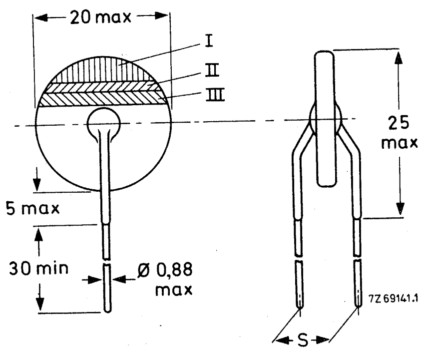


Fig. 1 S = 9 mm for types with C values up to 500. S = 10 mm for others, see table.

Marking

A three-band colour code as shown in Fig. 1. This code indicates the three figures following the zero in the last part of the catalogue number shown in Table 1. The colours are in accordance with the standard VDR resistor colour code, e.g. type 2322 553 01161 is coded brown, brown, blue (100 mA, 8 V). See Table 2.

Mass

See Table 1.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

ELECTRICAL DATA

Tolerance on voltage at I_{nom}		± 20% or ± 10%*
Maximum dissipation		1 W
Asymmetry	max.	2 %
Operating temperature range		
zero power		−25 to +125 °C
max. power		0 to + 55 °C

See further Table 1.

PACKAGING

100 resistors in a cardboard box.

* The 10% types have an extra silver tipping.

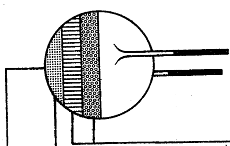
Table 1 Catalogue numbers 2322 553 0....

suffix of catalogue number 20% on V*	d.c. current I_{nom} mA	voltage at I_{nom} V	β	C approx.	mass g	S max (Fig. 1) mm
1161	100	8	0,25 to 0,40	14	1,7	9
1181	100	10	0,25 to 0,40	18	1,8	9
1201	100	12	0,25 to 0,40	21	1,9	9
1221	100	15	0,25 to 0,40	26	1,9	9
2181	10	10	0,25 to 0,40	32	1,9	9
2201	10	12	0,25 to 0,40	40	2,0	9
2221	10	15	0,25 to 0,40	48	2,0	9
2241	10	18	0,21 to 0,35	57	2,0	9
2261	10	22	0,21 to 0,35	60	2,1	9
2281	10	27	0,21 to 0,35	70	2,1	9
2301	10	33	0,18 to 0,25	85	2,1	9
2321	10	39	0,18 to 0,25	100	2,1	9
2341	10	47	0,18 to 0,25	130	2,1	9
2361	10	56	0,18 to 0,25	150	2,1	9
2381	10	68	0,18 to 0,25	180	2,1	9
2401	10	82	0,14 to 0,23	190	2,1	9
3381	1	68	0,14 to 0,23	230	2,1	9
3401	1	82	0,14 to 0,21	300	2,1	9
3421	1	100	0,14 to 0,21	350	2,3	9
3441	1	120	0,14 to 0,21	400	2,4	9
3461	1	150	0,14 to 0,21	500	2,6	9
3481	1	180	0,14 to 0,21	600	2,9	10
3501	1	220	0,14 to 0,21	750	3,3	10
3521	1	270	0,14 to 0,21	900	3,7	10
3541	1	330	0,14 to 0,21	1100	4,2	10

* For a 10% tolerance on voltage replace the last digit (1) of the catalogue number by a 2.

Table 2.

VDR standard



brown	= 100 mA
red	= 10 mA
orange	= 1 mA

silver tipped 10% tol.

untipped 20% tol.

brown/blue	= 8 V	orange/blue	= 56 V
brown/grey	= 10 V	orange/grey	= 68 V
red/black	= 12 V	yellow/black	= 82 V
red/red	= 15 V	yellow/red	= 100 V
red/yellow	= 18 V	yellow/yellow	= 120 V
red/blue	= 22 V	yellow/blue	= 150 V
red/grey	= 27 V	yellow/grey	= 180 V
orange/black	= 33 V	green/black	= 220 V
orange/red	= 39 V	green/red	= 270 V
orange/yellow	= 47 V	green/yellow	= 330 V

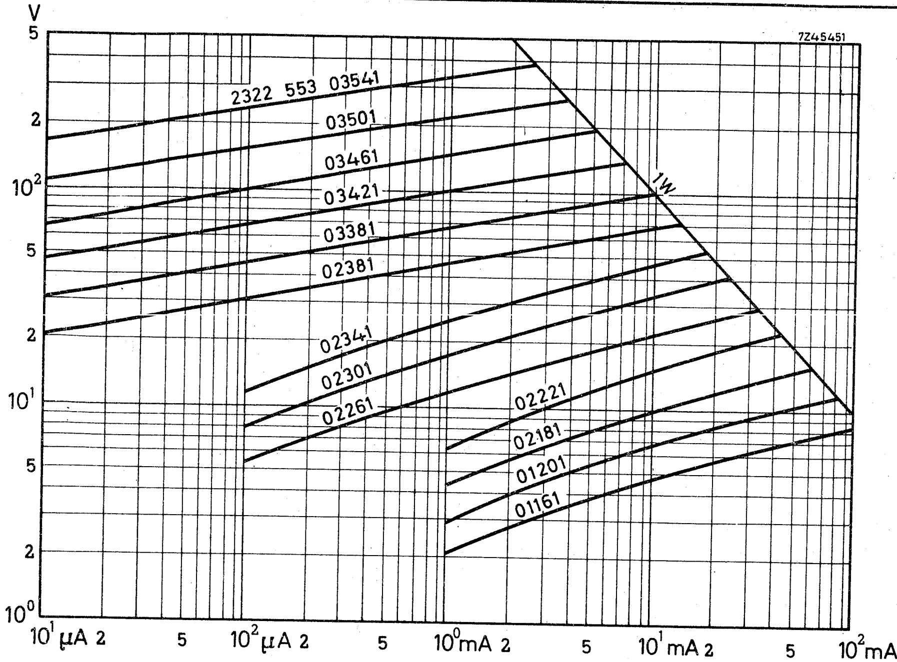


Fig. 2 Voltage/current characteristics.

VOLTAGE DEPENDENT RESISTORS

silicon carbide disc

QUICK REFERENCE DATA

D.C. voltage	
I_{nom} = 100 mA	8 to 18 V
I_{nom} = 10 mA	12 to 180 V
I_{nom} = 1 mA	150 to 330 V
β between 0,3 I_{nom} and 3 I_{nom}	0,14 to 0,40
Maximum dissipation	2 W
Operating temperature range	
zero power	−25 to +125 °C
max. power	0 to + 55 °C

APPLICATION

Voltage stabilization, contact protection and spark suppression.

DESCRIPTION

A disc of silicon carbide with axial tinned copper leads. The disc is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

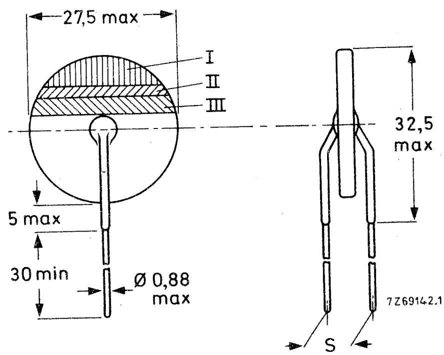


Fig. 1 S = 9 mm for types with C values up to 660. S = 10 mm for others, see table.

Marking

A three-band colour code as shown in Fig. 1. This code indicates the three figures following the zero in the last part of the catalogue number shown in Table 1. The colours are in accordance with the standard VDR resistor colour code, e.g. type 2322 554 01161 is coded brown, brown, blue (100 mA, 8 V). See Table 2.

Mass

See Table 1.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

ELECTRICAL DATA

Tolerance on voltage at I_{nom}		± 20% or ± 10%*
Maximum dissipation		2 W
Asymmetry	max.	2 %
Operating temperature range		
zero power		−25 to +125 °C
max. power		0 to + 55 °C

See further Table 1.

PACKAGING

50 resistors in a cardboard box.

* The 10% types have an extra silver tipping.

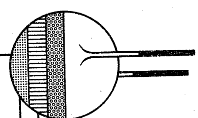
Table 1 Catalogue numbers 2322 554 0....

suffix of catalogue number 20% on V*	d.c. current I_{nom} mA	voltage at I_{nom} V	β	C approx.	mass g	S max (Fig. 1) mm
1161	100	8	0,25 to 0,40	14	2,9	9
1181	100	10	0,25 to 0,40	18	2,95	9
1201	100	12	0,25 to 0,40	21	3,0	9
1221	100	15	0,25 to 0,40	26	3,0	9
1241	100	18	0,25 to 0,40	32	3,05	9
2201	10	12	0,25 to 0,40	38	3,05	9
2221	10	15	0,25 to 0,40	47	3,1	9
2241	10	18	0,21 to 0,35	57	3,1	9
2261	10	22	0,21 to 0,35	60	3,2	9
2281	10	27	0,21 to 0,35	70	3,3	9
2301	10	33	0,18 to 0,25	84	3,4	9
2321	10	39	0,18 to 0,25	97	3,45	9
2341	10	47	0,18 to 0,25	125	3,5	9
2361	10	56	0,18 to 0,25	140	3,55	9
2381	10	68	0,18 to 0,25	175	3,6	9
2401	10	82	0,14 to 0,23	170	3,65	9
2421	10	100	0,14 to 0,23	210	3,7	9
2441	10	120	0,14 to 0,21	250	3,75	9
2461	10	150	0,14 to 0,21	320	3,8	9
2481	10	180	0,14 to 0,21	380	4,2	9
3461	1	150	0,14 to 0,21	450	4,6	9
3481	1	180	0,14 to 0,21	540	5,2	9
3501	1	220	0,14 to 0,21	660	5,7	9
3521	1	270	0,14 to 0,21	810	5,7	10
3541	1	330	0,14 to 0,21	980	6,0	10

* For a 10% tolerance on voltage replace the last digit (1) of the catalogue number by a 2.

Table 2.

VDR standard



brown	=	100 mA
red	=	10 mA
orange	=	1 mA

silver tipped 10% tol.

untipped 20% tol.

brown/blue = 8 V		orange/blue = 56 V	
brown/grey = 10 V		orange/grey = 68 V	
red/black = 12 V		yellow/black = 82 V	
red/red = 15 V		yellow/red = 100 V	
red/yellow = 18 V		yellow/yellow = 120 V	
red/blue = 22 V		yellow/blue = 150 V	
red/grey = 27 V		yellow/grey = 180 V	
orange/black = 33 V		green/black = 220 V	
orange/red = 39 V		green/red = 270 V	
orange/yellow = 47 V		green/yellow = 330 V	

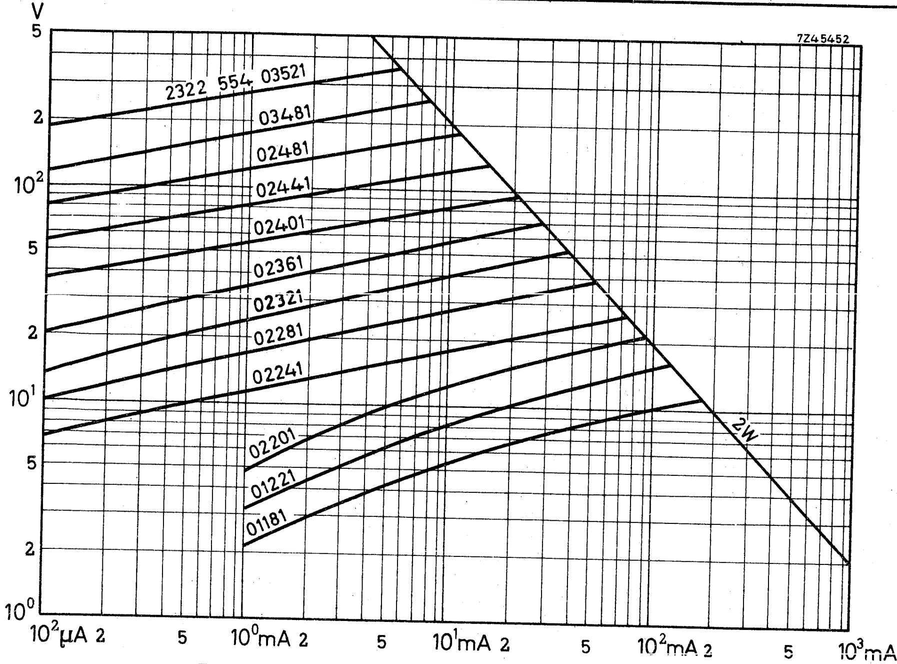


Fig. 2 Voltage/current characteristics.

VOLTAGE DEPENDENT RESISTORS

silicon carbide disc

QUICK REFERENCE DATA

D.C. voltage	
I_{nom} = 100 mA	8 to 33 V
I_{nom} = 10 mA	22 to 270 V
I_{nom} = 1 mA	220 to 330 V
β between 0,3 I_{nom} and 3 I_{nom}	0,14 to 0,40
Maximum dissipation	3 W
Operating temperature range	
zero power	−25 to +125 °C
max. power	0 to + 55 °C

APPLICATION

Voltage stabilization, contact protection and spark suppression.

DESCRIPTION

A disc of silicon carbide with axial tinned copper leads. The disc is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

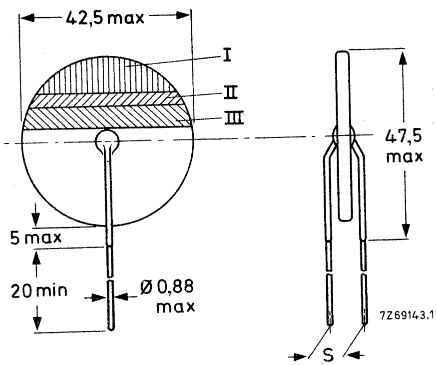


Fig. 1 For S see Table 1.

Marking

A three-band colour code as shown in Fig. 1. This code indicates the three figures following the zero in the last part of the catalogue number shown in Table 1. The colours are in accordance with the standard VDR resistor colour code, e.g. type 2322 555 01161 is coded brown, brown, blue (100 mA, 8 V). See Table 2.

Mass

See Table 1.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

ELECTRICAL DATA

Tolerance on voltage at I_{nom}		± 20% or ± 10%*
Maximum dissipation		3 W
Asymmetry	max.	2 %

Operating temperature range

zero power	−25 to +125 °C
max. power	0 to + 55 °C

See further Table 1.

PACKAGING

25 resistors in a cardboard box.

* The 10% types have an extra silver tipping.

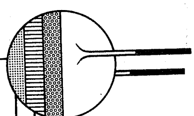
Table 1 Catalogue numbers 2322 555 0....

suffix of catalogue number 20% on V*	d.c. current I_{nom} mA	voltage at I_{nom} V	β	C approx.	mass g	S max (Fig. 1) mm
1161	100	8	0,25 to 0,40	14	8	9
1181	100	10	0,25 to 0,40	18	8	9
1201	100	12	0,25 to 0,40	21	8	9
1221	100	15	0,25 to 0,40	26	8	9
1241	100	18	0,25 to 0,40	32	8	9
1261	100	22	0,25 to 0,40	39	8	9
1281	100	27	0,25 to 0,40	48	8	9
1301	100	33	0,21 to 0,35	53	8	9
2261	10	22	0,21 to 0,35	60	8	9
2281	10	27	0,21 to 0,35	70	8	9
2301	10	33	0,18 to 0,25	84	8	9
2321	10	39	0,18 to 0,25	97	8	9
2341	10	47	0,18 to 0,25	125	10	9
2361	10	56	0,18 to 0,25	140	10	9
2381	10	68	0,18 to 0,25	175	10	9
2401	10	82	0,14 to 0,23	170	10	9
2421	10	100	0,14 to 0,23	210	10	9
2441	10	120	0,14 to 0,21	250	10	9
2461	10	150	0,14 to 0,21	320	10	9
2481	10	180	0,14 to 0,21	380	10	9
2501	10	220	0,14 to 0,21	460	10	10
2521	10	270	0,14 to 0,21	550	10	10
3501	1	220	0,14 to 0,21	660	10	10
3521	1	270	0,14 to 0,21	810	10	10
3541	1	330	0,14 to 0,21	980	10	11

* For a 10% tolerance on voltage replace last digit (1) of the catalogue number by a 2.

Table 2.

VDR standard



brown	= 100 mA
red	= 10 mA
orange	= 1 mA

silver tipped 10% tol.

untipped 20% tol.

brown/blue	= 8 V	orange/blue	= 56 V
brown/grey	= 10 V	orange/grey	= 68 V
red/black	= 12 V	yellow/black	= 82 V
red/red	= 15 V	yellow/red	= 100 V
red/yellow	= 18 V	yellow/yellow	= 120 V
red/blue	= 22 V	yellow/blue	= 150 V
red/grey	= 27 V	yellow/grey	= 180 V
orange/black	= 33 V	green/black	= 220 V
orange/red	= 39 V	green/red =	= 270 V
orange/yellow	= 47 V	green/yellow	= 330 V

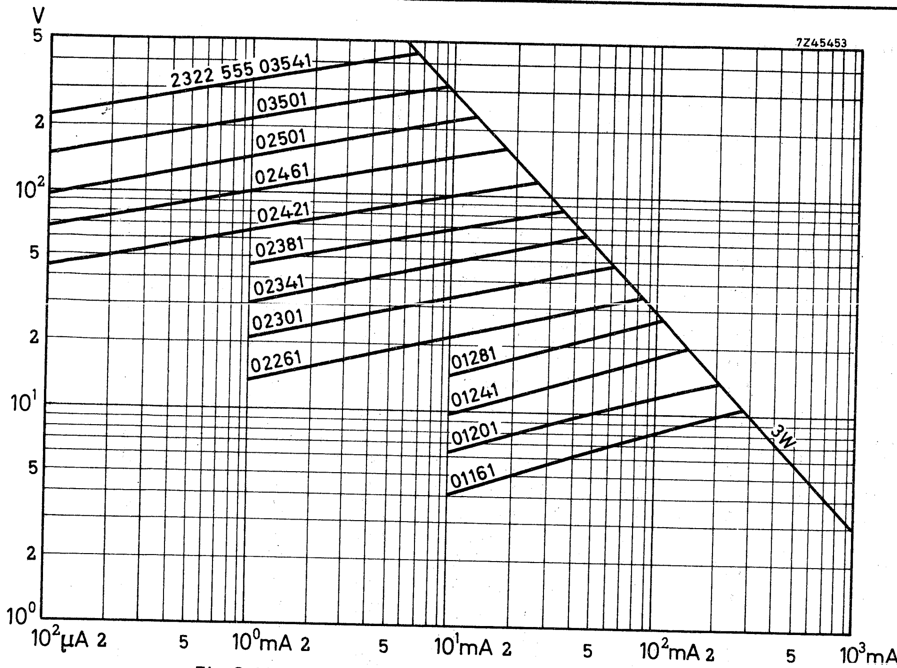


Fig. 2 Voltage/current characteristics.

VOLTAGE DEPENDENT RESISTORS

silicon carbide rod

QUICK REFERENCE DATA

D.C. voltage	
I_{nom} = 10 mA	470 to 1300 V
I_{nom} = 2 mA	950 V
I_{nom} = 1 mA	300 V
β-values	0,16 to 0,25
Maximum dissipation	0,8 W
Operating temperature range	
zero power	−25 to +125 °C
max. power	0 to + 55 °C

APPLICATION

Voltage stabilization, contact protection, etc.

DESCRIPTION

A rod of silicon carbide with axial tinned copper leads. The rod is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

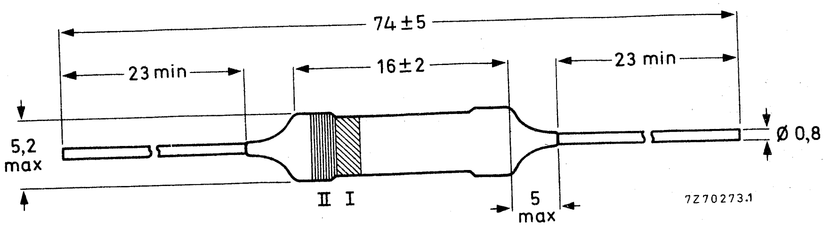


Fig. 1.

Marking

The thermistors are colour coded according to the table and Fig. 1.

Mass

0,9 g approximately

Mounting

In any position by soldering

Robustness of terminations

Tensile strength	20 N
Bending	10 N
Torsion	3 times

Soldering

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

ELECTRICAL DATA

catalogue number	d.c. current I_{nom} mA	voltage at I_{nom} V*	tolerance on V %	β-value	colour code (see Fig. 1)	
					band I	band II
2322 564 02582	10	470	± 10	0,20-0,25	green	
2322 564 02602	10	560	± 10	0,18-0,23	blue	
2322 564 02622	10	680	± 10	0,18-0,23	violet	
2322 564 02681	10	1200	± 20	0,17-0,22	grey	
2322 564 02682	10	1200	± 10	0,17-0,22	brown	
2322 564 90014	10	910	± 10	0,17-0,22	white	
2322 564 90015	10	1300	± 10	0,16-0,21	red	
2322 564 90005	2	950	± 10	0,16-0,21	black	blue
2322 564 90016	1	300	± 20	0,18-0,25	yellow	

Dissipation factor	20 mW/K
Temperature coefficient at 1 mA between +25 and +100 °C	−0,1%/K
Maximum dissipation	0,8 W
Asymmetry **	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to + 55 °C

PACKAGING

100 resistors in a cardboard box.

* The voltage is so measured, that the internal heat development is negligible.
** Covered by the specified voltage tolerance.

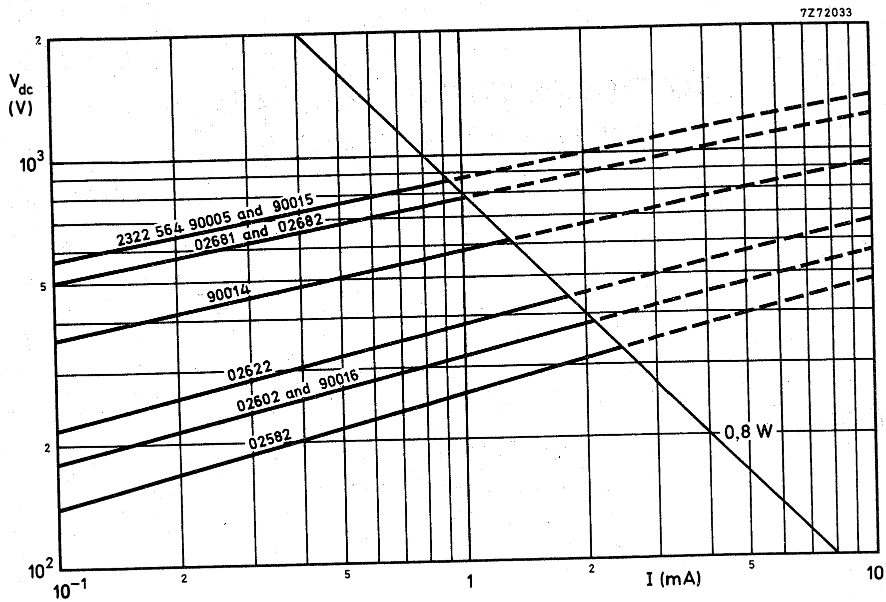
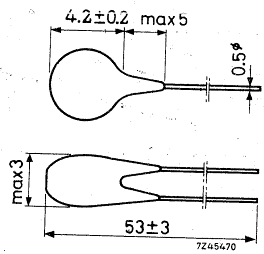


Fig. 2 Voltage/current characteristics.

VOLTAGE DEPENDENT RESISTORS

small disc types for special purposes



Type 2322 565 900001 has been developed for use in small battery motors, for example. It can be mounted in the rotor to protect the collector and to suppress interference to radio and television.

Current at 5 V d.c.	⩽ 1 mA
Current at 28 V d.c.	⩾ 10 mA
W_{max}	0,1 W

A special range of VDR discs has been developed for use in colour television.

I mA	E V	tolerance on voltage	colour dip code	catalogue number
1	6	± 20%	red	2322 565 90002
1	9	± 20%	orange	2322 565 90003
1	12	± 15%	yellow	2322 565 90004
1	15	± 15%	green	2322 565 90005
1	18	± 12%	blue	2322 565 90006

VOLTAGE DEPENDENT RESISTORS

titanium oxide disc

QUICK REFERENCE DATA

Voltage at 1 mA d.c.	2,7 to 68 V
β between 1 mA and 10 mA	max. 0,28
Maximum dissipation	0,25 W
Operating temperature range	
at zero power	−25 to +85 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for applications requiring a low β-value at a low voltage.

DESCRIPTION

A titanium oxide disc with axial tinned copper leads. The disc is coated with tan coloured lacquer. It is not insulated.

MECHANICAL DATA

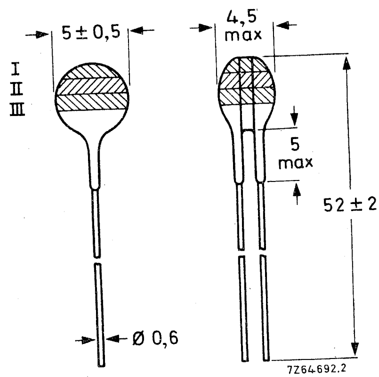


Fig. 1.

Marking

A three-band colour code as shown in Fig. 1. This code indicates the three figures following the zero in the last part of the catalogue number shown in Table 1. The colours are in accordance with the standard VDR resistor colour code, e.g. type 2322 581 03041 is coded orange, black, yellow (1 mA, 2,7 V). See Table 2.

Mass

0,4 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	260 ± 5 °C, max. 10 s

Impact

Free fall	1000 mm

Resistance to solvents

Resist to freon TMC and trichlorotrifluoroethane 70% + isopropyl alcohol 30%.

ELECTRICAL DATA

Tolerance on voltage at 1 mA		± 20% and ± 10%
Temperature coefficient measured at 10 mA between +25 and +55 °C		−0,25%/K
Dissipation factor		7 mW/K approx.
Maximum dissipation		0,25 W
Asymmetry	max.	2%
Operating temperature range		
zero power		−25 to +85 °C
maximum power		0 to +55 °C

PACKAGING

250 resistors in a cardboard box.

* The 10% types have an extra silver tipping.

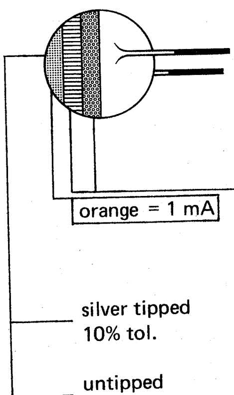
Table 1 Catalogue numbers 2322 581 0....

suffix of catalogue number 20% on V *	d.c. voltage at 1 mA V	max. peak current (8 x 20 μs) A	protection level (max. clamping voltage at 10 A) for +20% at V at 1 mA V	β between 1-10 mA	capacitance at 10 kHz nF
03041	2,7	315	40	0,28	40
03061	3,3	300	42	0,28	35
03081	3,9	290	45	0,28	29
03101	4,7	275	48	0,25	24
03121	5,6	265	52	0,25	21
03141	6,8	250	58	0,22	18
03161	8,2	240	64	0,22	16
03181	10	225	72	0,22	14
03201	12	215	82	0,22	12
03221	15	210	96	0,22	11
03241	18	195	110	0,22	9,5
03261	22	185	125	0,20	8
03281	27	175	200	0,20	7
03301	33	165	235	0,20	5,5
03321	39	155	270	0,20	5
03341	47	150	315	0,20	4
03361	56	145	370	0,20	3
03381	68	135	430	0,20	2

* For a 10% tolerance on voltage replace last digit (1) in the catalogue number by a 2.

Table 2

VDR standard



black/yellow	=	2,7 V	red/red	=	15 V
black/blue	=	3,3 V	red/yellow	=	18 V
black/grey	=	3,9 V	red/blue	=	22 V
brown/black	=	4,7 V	red/grey	=	27 V
brown/red	=	5,6 V	orange/black	=	33 V
brown/yellow	=	6,8 V	orange/red	=	39 V
brown/blue	=	8,2 V	orange/yellow	=	47 V
brown/grey	=	10 V	orange/blue	=	56 V
red/black	=	12 V	orange/grey	=	68 V

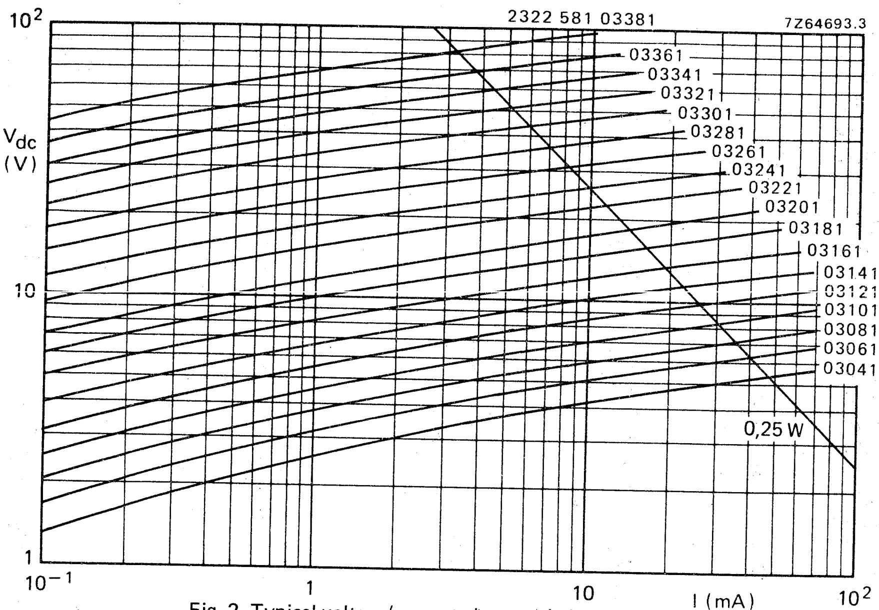


Fig. 2 Typical voltage/current characteristics.

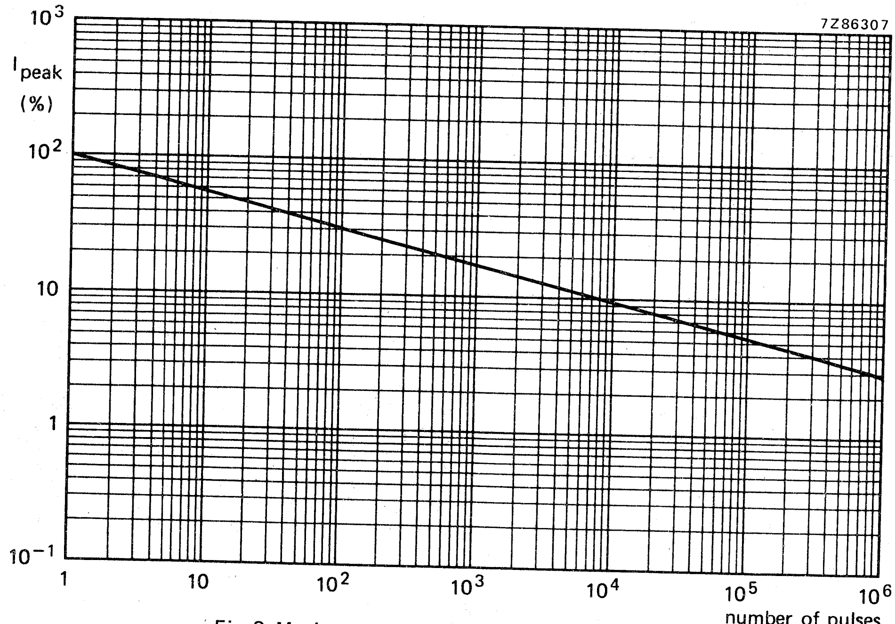


Fig. 3 Maximum applicable transient current.

VOLTAGE-DEPENDENT RESISTORS

zinc oxide disc

QUICK REFERENCE DATA

Maximum a.c. voltage (r.m.s.)	60 to 460 V
Maximum d.c. voltage	85 to 615 V
Maximum non-repetitive transient current (8/20 μs)	400 A
Climatic category	40/125/56
Packaging	
2322 592 3....	in tape on reel
2322 592 6....	in bulk in box

APPLICATION

Suppression of transients, contact protection, spark suppression, suppression of line transients in telephony.

DESCRIPTION

A disc of low-β ceramic with two solid tinned copper wires. The VDRs are lacquered, but not insulated.

Dimensions in mm

MECHANICAL DATA

Outlines

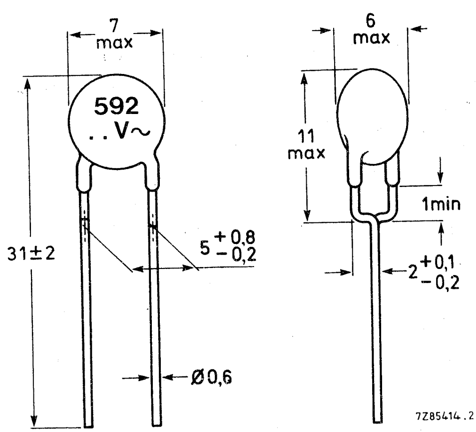


Fig. 1.

Marking

The resistors are marked with their serial number (592) and the maximum r.m.s. working voltage (see Fig. 1 and Table 1).

Mass

Approx. 0,5 g.

Mounting

In any position by soldering. Leads should be as short as possible. The VDR should be mounted near the equipment or component to be protected.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	260 ± 5 °C; 10 ± 1 s

Inpact

Free fall	1000 mm

Resistance to solvents

According to IEC 68-2-45, resist to R113

Inflammability

Self-extinguishing according to IEC draft 50D, severity 10 s

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of + 23 ± 1 °C

Thermal resistance, body to air	approx.	80	K/W
Temperature coefficient at 1 mA, measured between + 25 and + 85 °C	max.	−0,065	%/K
Maximum average dissipation (including transients)		100	mW
Maximum non-repetitive transient current (8/20 μs) (note 5)		400	A
Climatic category		40/125/56	

See further Table 1

Table 1 Catalogue numbers 2322 592 3.... and 2322 592 6....

suffix of catalogue number	MAXIMUM RATINGS				CHARACTERISTICS			
	r.m.s. working voltage (notes 3,4)	d.c. working voltage (note 3)	transient energy (notes 5, 6)		varistor voltage ± 10% (note 1)		maximum clamping voltage at 50 A (note 2)	typical capacitance at 1 kHz
			8/20 μs	10/1000 μs	min.	max.		
	V	V	J	J	V	V	V	pF
6002	60	85	2,3	2,7	90	110	220	190
7502	75	100	2,6	3,5	108	132	240	160
9502	95	125	3,0	4,0	135	165	295	130
1312	130	170	4,5	5,5	185	225	405	100
1512	150	200	5,0	6,5	216	264	470	90
1712	175	225	5,5	7,0	243	297	525	80
2312	230	300	7,0	9,0	324	396	675	70
2512	250	320	7,5	10,0	351	429	745	60
2712	275	350	8,5	11,0	387	473	820	60
3012	300	385	9,5	12,0	423	517	905	50
4212	420	560	14,0	17,0	612	748	1340	50
4612	460	615	16,0	20,0	675	825	1480	50

Notes

1. Voltage at a current of 1 mA, after an impulse time of 50 ms with a rise time of 10 μs to 1 ms.
2. Measured with a standard impulse current 8/20 μs, defined in IEC 60-2 section 6, par. 16-1.
3. Derating, see Fig. 4.
4. Sinusoidal voltage assumed. For a non-sinusoidal voltage, the crest voltage x 0,707 should be used for type selection.
5. A current impulse of 8/20 μs (defined in IEC 60-2 section 6) is used as a standard for impulse current and clamping voltage ratings. The transient energy is given for one impulse applied during the life of the component. Figure 3 gives the derating for different numbers and longer duration of impulses. The shift of the varistor voltage does not exceed ± 5%.
6. High energy surges are generally of longer duration. The max. energy for 1 impulse 10/1000 μs is given as a reference for long duration impulses. This impulse can be characterized by peak current I_p and impulse width t_2 (virtual time to half I_p value, defined in IEC 60-2 section 6), see Fig. 5. If V_p is the clamping voltage corresponding to I_p, the energy absorbed in the VDR is determined by equation $E = K.V_p.I_p.t_2$; K depends on t_2. When t_1 is 8 to 10 μs and t_2 = 20 μs, K = 1; when t_2 = 50 μs, K = 1,2; when t_2 = 100 μs, K = 1,3; when t_2 = 1000 μs, K = 1,4.

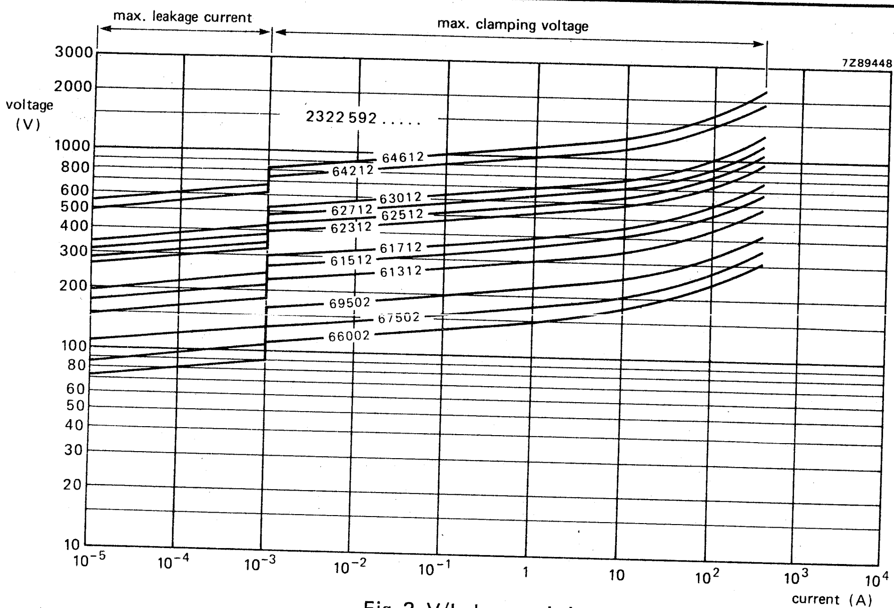


Fig. 2 V/I characteristics.

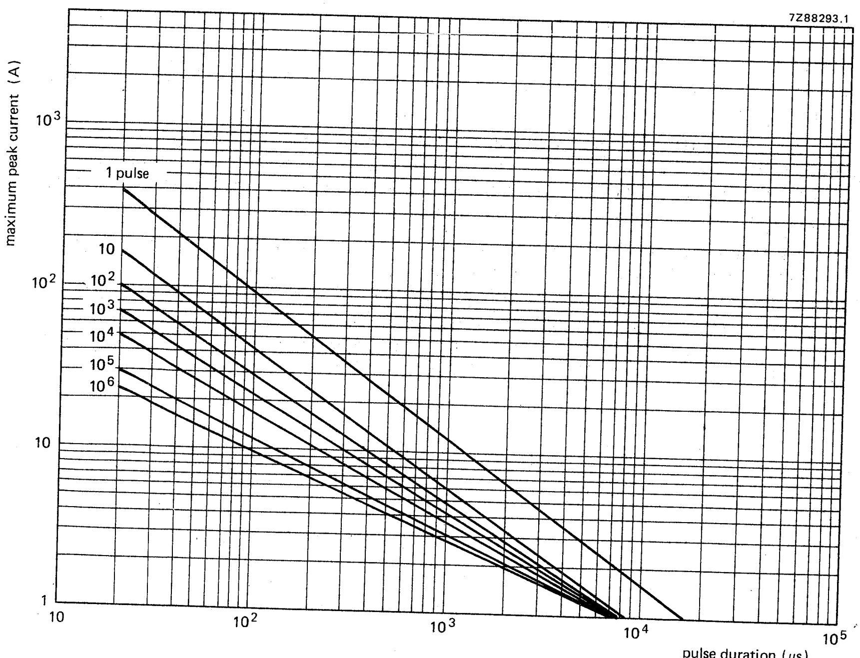


Fig. 3 Max. applicable transient current as a function of pulse duration.

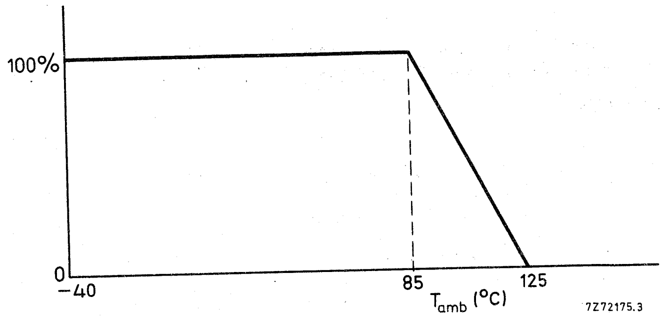


Fig. 4 Derating of max. d.c. and r.m.s. working voltage with temperature.

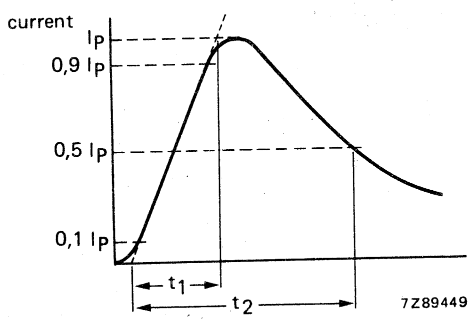


Fig. 5.

PACKAGING

Types 2322 592 3.... are supplied on tape on reel. A reel contains 1500 resistors.
Types 2322 592 6.... are supplied in bulk, 500 resistors per cardboard box.

Configuration of the tape

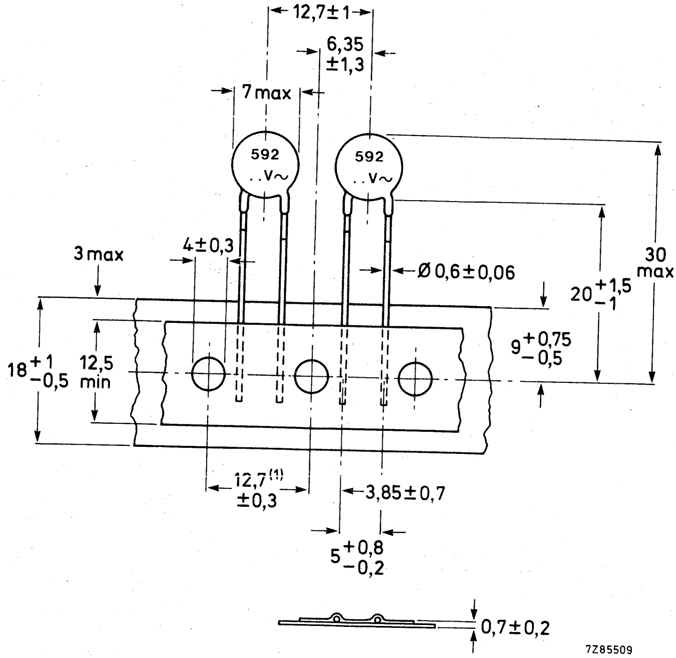


Fig. 6 Types 2322 592 3.... on tape.

(1) Cumulative pitch error: 1 mm/20 pitch.

VOLTAGE-DEPENDENT RESISTORS

zinc oxide disc

QUICK REFERENCE DATA

Maximum a.c. voltage (r.m.s.)	60 to 460 V
Maximum d.c. voltage	85 to 615 V
Maximum non-repetitive transient current (8/20 μs)	1200 A
Climatic category	40/125/56
Packaging	
2322 593 3....	in tape on reel
2322 593 6....	in bulk in box

APPLICATION

Suppression of transients, contact protection, spark suppression, suppression of line transients in telephony.

DESCRIPTION

A disc of low-β ceramic with two solid tinned copper wires. The VDRs are lacquered, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

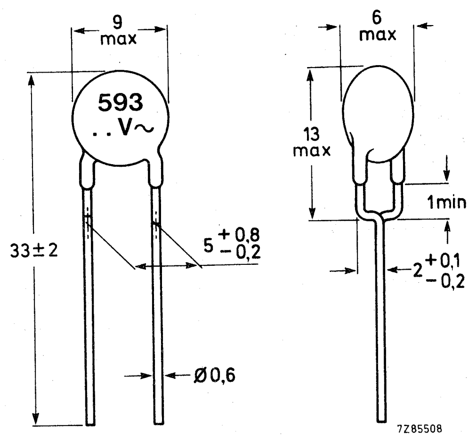


Fig. 1.

Marking

The resistors are marked with their serial number (593) and the maximum r.m.s. working voltage (see Fig. 1 and Table 1).

Mass

Approx.	0,7 g

Mounting

In any position by soldering. Leads should be as short as possible. The VDR should be mounted near the equipment or component to be protected.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	260 ± 5 °C; 10 ± 1 s

Impact

Free fall	1000 mm

Resistance to solvents

According to IEC 68-2-45, resist to R113 at 23 °C

Inflammability

Self-extinguishing according to IEC 50D, severity 10 s

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of +23 ± 1 °C

Thermal resistance, body to air	approx.	70 K/W
Temperature coefficient at 1 mA, measured between +25 and +85 °C	max.	−0,065 %/K
Maximum average dissipation (including transients)		250 mW
Maximum non-repetitive transient current (8/20 μs) (note 5)		1200 A
Climatic category		40/125/56

See further Table 1

Table 1 Catalogue numbers 2322 593 3... and 2322 593 6....

suffix of catalogue number	MAXIMUM RATINGS				CHARACTERISTICS			
	r.m.s. working voltage (notes 3, 4)	d.c. working voltage (note 3)	transient energy (notes 5, 6)		varistor voltage ± 10% (note 1)		maximum clamping voltage at 100 A (note 2)	typical capacitance at 1 kHz
			8/20 μs	10/1000 μs	min.	max.		
	V	V	J	J	V	V	V	pF
6002	60	85	6	4,6	90	110	210	600
7502	75	100	9	5,5	108	132	250	530
9502	95	125	9,5	7,0	135	165	310	460
1312	130	170	14	9,5	185	225	425	390
1512	150	200	17	11,0	216	264	485	340
1712	175	225	20	13,0	243	297	550	250
2312	230	300	22	16,0	324	396	720	190
2512	250	320	23	18,0	351	429	780	160
2712	275	350	26	20,0	387	473	850	140
3012	300	385	29	22,0	423	517	930	110
4212	420	560	42	30,0	612	748	1350	90
4612	460	615	48	32,0	675	825	1490	80

Notes

1. Voltage at a current of 1 mA, after an impulse time of 50 ms wih a rise time of 10 μs to 1 ms.
2. Measured with a standard impulse current 8/20 μs, defined in IEC 60-2 section 6, par. 16-1.
3. Derating, see Fig. 4.
4. Sinusoidal voltage assumed. For a non-sinusoidal voltage, the crest voltage x 0,707 should be used for type selection.
5. A current impulse of 8/20 μs (defined in IEC 60-2 section 6) is used as a standard for impulse current and clamping voltage ratings. The transient energy is given for one impulse applied during the life of the component. Figure 3 gives the derating for different numbers and longer duration of impulses. The shift of the varistor voltage does not exceed ±5%.
6. High energy surges are generally of longer duration. The max. energy for 1 impulse 10/1000 μs is given as a reference for long duration impulses. This impulse can be characterized by peak current I_p and impulse width t_2 (virtual time to half I_p value, defined in IEC 60-2 section 6), see Fig. 5. If V_p is the clamping voltage corresponding to I_p, the energy absorbed in the VDR is determined by equation $E = K. V_p.I_p.t_2$; K depends on t_2. When t_1 is 8 to 10 μs and t_2 = 20 μs, K = 1; when t_2 = 50 μs, K = 1,2; when t_2 = 100 μs, K = 1,3; when t_2 = 1000 μs, K = 1,4.

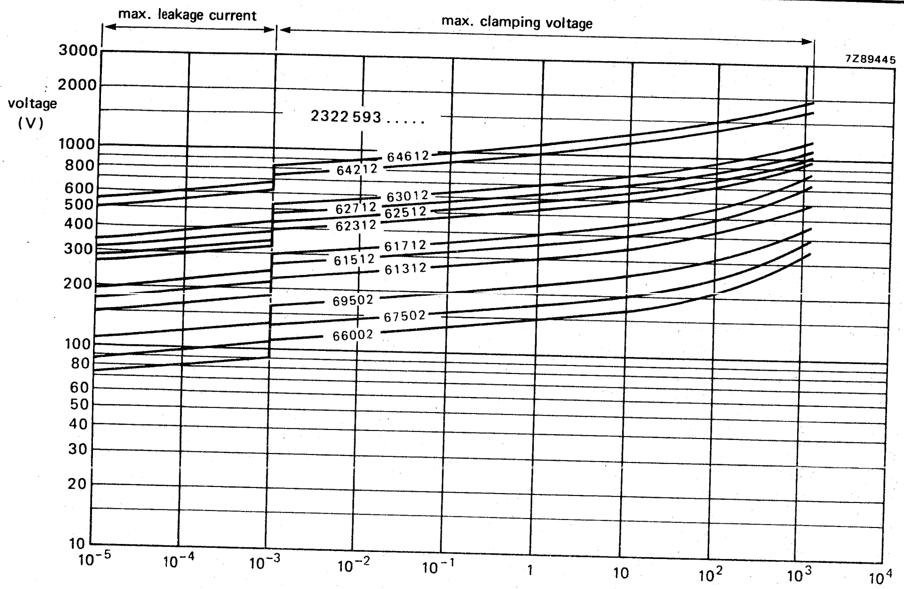


Fig. 2 V/I characteristics.

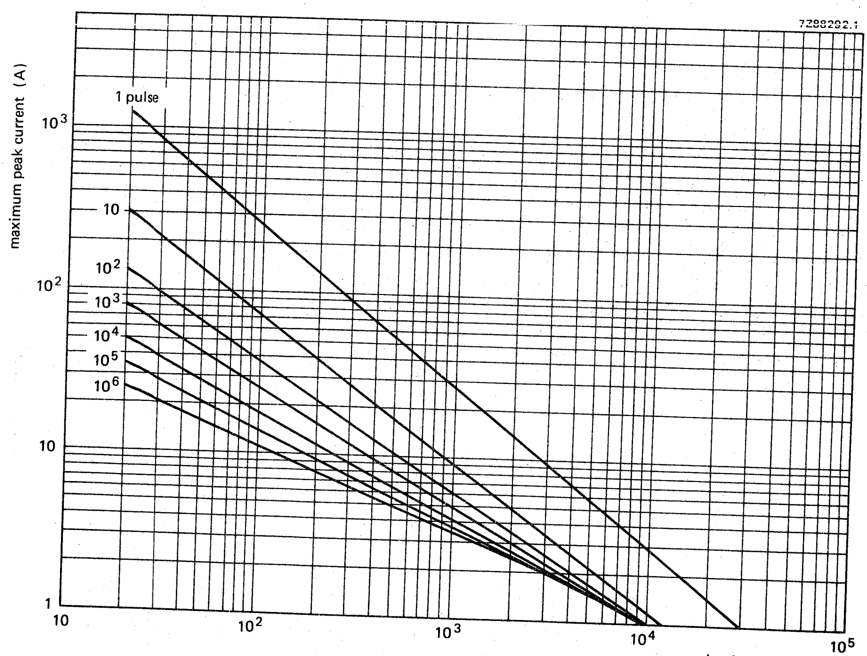


Fig. 3 Max. applicable transient current as a function of pulse duration.

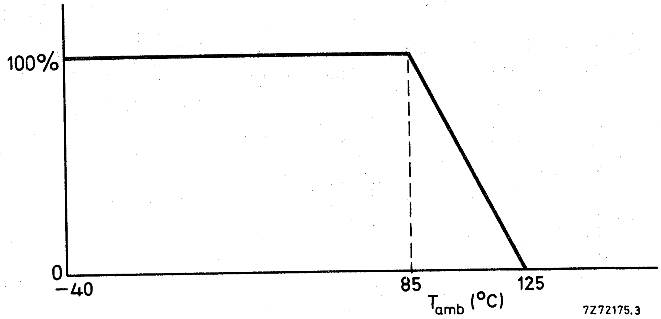


Fig. 4 Derating of max. d.c. and r.m.s. working voltage with temperature.

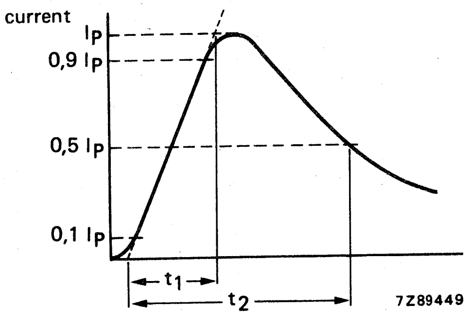


Fig. 5.

PACKAGING

Types 2322 593 3.... are supplied on tape on reel. A reel contains 1500 resistors.
Types 2322 593 6.... are supplied in bulk, 500 resistors per cardboard box.

Configuration of the tape

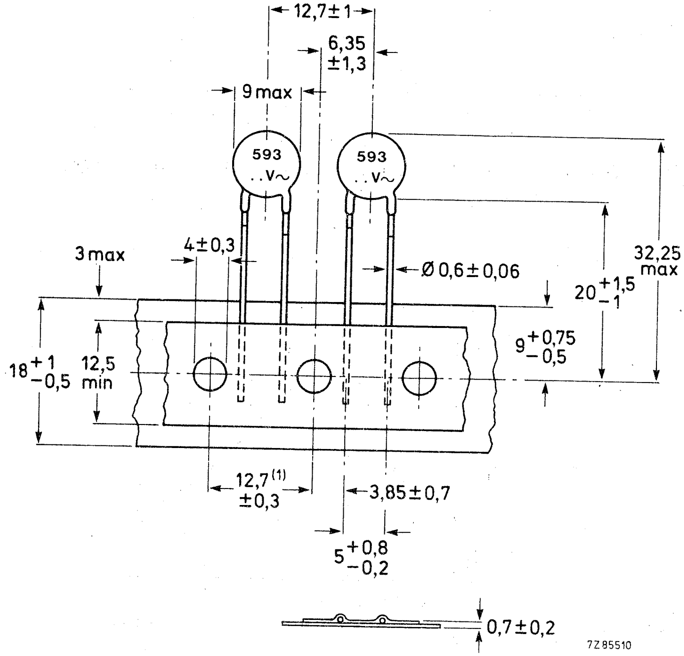


Fig. 6 Types 2322 593 3.... on tape.

(1) Cumulative pitch error: 1 mm/20 pitch.

VOLTAGE-DEPENDENT RESISTORS

zinc oxide disc

QUICK REFERENCE DATA

Maximum a.c. voltage (r.m.s.)	60 to 460 V
Maximum d.c. voltage	85 to 615 V
Maximum non-repetitive transient current (8/20 μs)	4500 A
Climatic category	40/125/56
Packaging	in bulk in box

APPLICATION

Suppression of transients, contact protection, spark suppression, suppression of line transients in telephony.

DESCRIPTION

A disc of low-β ceramic with two solid tinned copper wires. The VDRs are lacquered, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

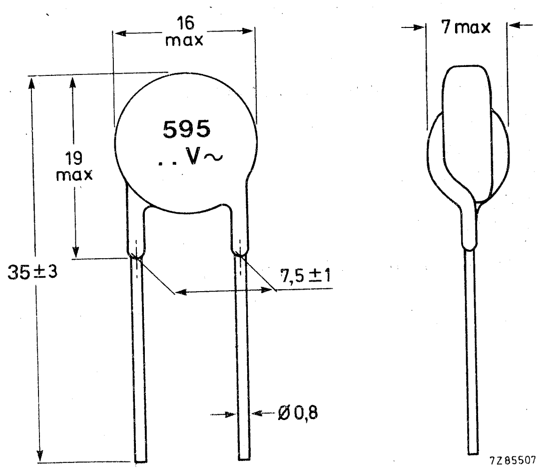


Fig. 1.

Marking

The resistors are marked with their serial number (595) and the maximum r.m.s. working voltage (see Fig. 1 and Table 1).

Mass

Approx.	2 g

Mounting

In any position by soldering. Leads should be as short as possible. The VDR should be mounted near the equipment or component to be protected.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	260 ± 5 °C; 10 ± 1 s

Impact

Free fall	1000 mm

Resistance to solvents

According to IEC 68-2-45, resist to R113, at 23 °C

Inflammability

Self-extinguishing according to IEC draft 50D, severity 10 s

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of + 23 ± 1 °C

Thermal resistance, body to air	approx.	50	K/W
Temperature coefficient at 1 mA, measured between + 25 and + 85 °C	max.	−0,065	%/K
Maximum average dissipation (including transients)		600	mW
Maximum non-repetitive transient current (8/20 μs) (note 5)		4500	A
Climatic category		40/125/56	

See further Table 1

Table 1 Catalogue numbers 2322 595 6....

suffux of catalogue number	MAXIMUM RATINGS				CHARACTERISTICS			
	r.m.s. working voltage (notes 3,4)	d.c. working voltage (note 3)	transient energy (notes 5, 6)		varistor voltage ± 10% (note 1)		maximum clamping voltage at 100 A (note 2)	typical capacitance at 1 kHz
			8/20 µs	10/1000 µs	min.	max.		
	V	V	J	J	V	V	V	pF
6002	60	85	27	12	90	110	175	2300
7502	75	100	34	14	108	132	210	1900
9502	95	125	42	19	135	165	270	1700
1312	130	170	53	26	185	225	360	1300
1512	150	200	61	30	216	264	415	1100
1712	175	225	70	35	243	297	480	920
2312	230	300	89	48	324	396	650	700
2512	250	320	98	51	351	429	695	630
2712	275	350	109	56	387	473	765	600
3012	300	385	116	61	423	517	835	520
4212	420	560	150	93	612	748	1225	400
4612	460	615	167	102	675	825	1342	380

Notes

1. Voltage at a current of 1 mA, after an impulse time of 50 ms with a rise time of 10 µs to 1 ms.
2. Measured with a standard impulse current 8/20 µs, defined in IEC 60-2 section 6, par. 16-1.
3. Derating, see Fig. 4.
4. Sinusoidal voltage assumed. For a non-sinusoidal voltage, the crest voltage x 0,707 should be used for type selection.
5. A current impulse of 8/20 µs (defined in IEC 60-2 section 6) is used as a standard for impulse current and clamping voltage ratings. The transient energy is given for one impulse applied during the life of the component. Figure 3 gives the derating for different numbers and longer duration of impulses. The shift of the varistor voltage does not exceed ± 5%.
6. High energy surges are generally of longer duration. The max. energy for 1 minute 10/1000 µs is given as a reference for long duration impulses. This impulse can be characterized by peak current I_p and impulse width t_2 (virtual time to half I_p value, defined in IEC 60-2 section 6), see Fig. 5. If V_p is the clamping voltage corresponding to I_p, the energy absorbed in the VDR is determined by equation $E = K.V_p.I_p.t_2$; K depends on t_2. When t_1 is 8 to 10 µs and t_2 = 20 µs, K = 1; when t_s = 50 µs, K = 1,2; when t_2 = 100 µs, K = 1,3; when t_2 = 1000 µs, K = 1,4.

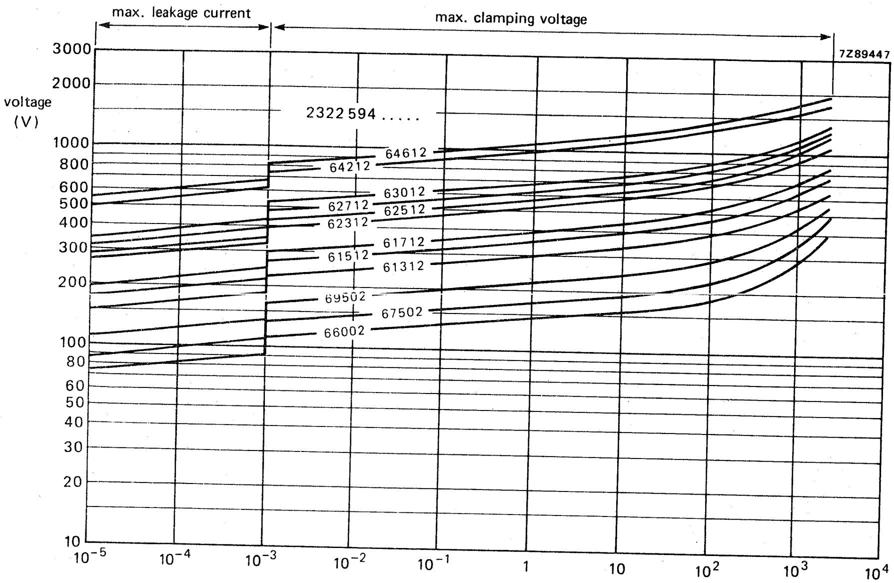


Fig. 2 V/I characteristics.

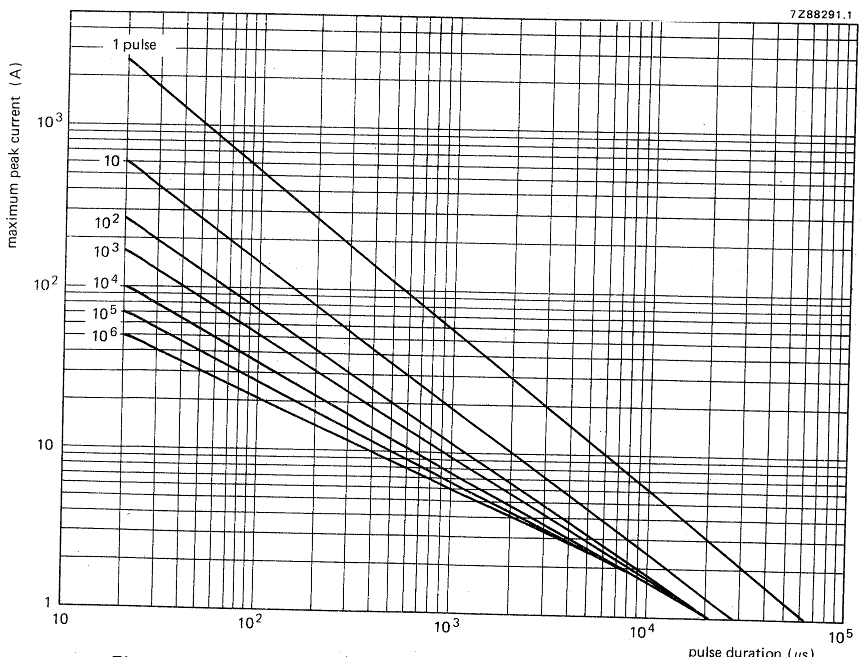


Fig. 3 Max. applicable transient current as a function of pulse duration.

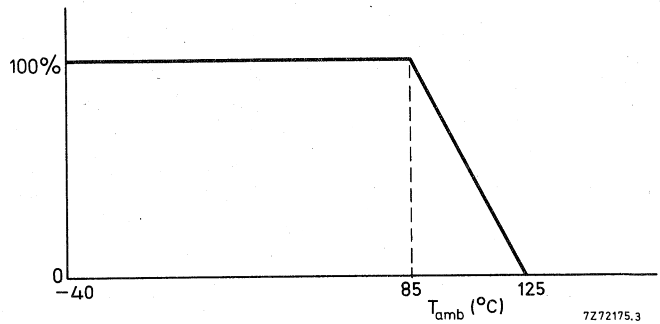


Fig. 4 Derating of max. d.c. and r.m.s. working voltage with temperature.

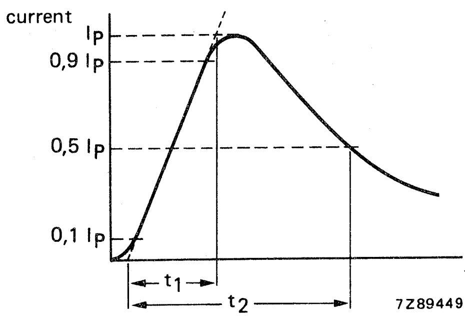


Fig. 5.

PACKAGING

The resistors 2322 595 6.... are supplied in bulk packing only in boxes of 250.

VOLTAGE-DEPENDENT RESISTORS

zinc oxide disc

QUICK REFERENCE DATA

Maximum a.c. voltage (r.m.s.)	60 to 460 V
Maximum d.c. voltage	85 to 615 V
Maximum non-repetitive transient current (8/20 μs)	2500 A
Climatic category	40/125/56
Packaging	in bulk in box

APPLICATION

Suppression of transients, contact protection, spark suppression, suppression of line transients in telephony.

DESCRIPTION

A disc of low-β ceramic with two solid tinned copper wires. The VDRs are lacquered, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

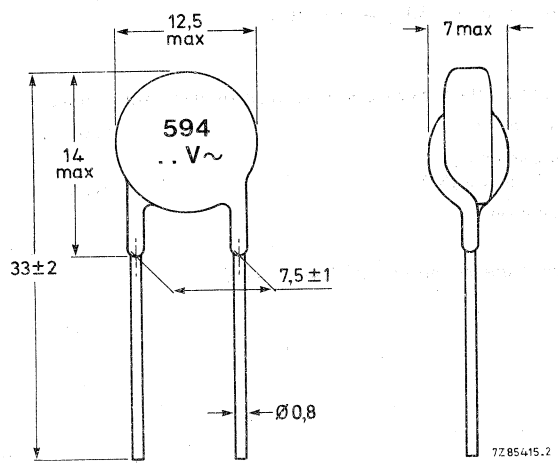


Fig. 1.

Marking

The resistors are marked with their serial number (594) and the maximum r.m.s. working voltage (see Fig. 1 and Table 1).

Mass

Approx.	1,5 g

Mounting

In any position by soldering. Leads should be as short as possible. The VDR should be mounted near the equipment or component to be protected.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s.
Resistance to heat	260 ± 5 °C; 10 ± 1 s

Impact

Free fall	1000 mm

Resistance to solvents

According to IEC 68-2-45, resist to R113 at 23 °C

Inflammability

Self-extinguishing according to IEC 50D, severity 10 s

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of + 23 ± 1 °C

Thermal resistance, body to air	approx.	60	K/W
Temperature coefficient at 1 mA, measured between + 25 and + 85 °C	max.	–0,065	%/K
Maximum average dissipation (including transients)		400	mW
Maximum non-repetitive transient current (8/20 μs) (note 5)		2500	A
Climatic category		40/125/56	

See further Table 1

Table 1 Catalogue numbers 2322 594 6....

suffix of catalogue number	MAXIMUM RATINGS				CHARACTERISTICS			
	r.m.s. working voltage (notes 3,4)	d.c. working voltage (note 3)	transient energy (notes 5, 6)		varistor voltage ± 10% (note 1)		maximum clamping voltage at 100 A (note 2)	typical capacitance at 1 kHz
			8/20 µs	10/1000 µs	min.	max.		
	V	V	J	J	V	V	V	pF
6002	60	85	18	8	90	110	185	1200
7502	75	100	21	10	108	132	225	1000
9502	95	125	25	12	135	165	285	900
1312	130	170	30	16	185	225	385	730
1512	150	200	35	18	216	264	455	600
1712	175	225	40	22	243	297	520	480
2312	230	300	50	29	324	396	686	360
2512	250	320	58	32	351	429	740	320
2712	275	350	61	35	387	473	815	290
3012	300	385	65	38	423	517	880	240
4212	420	560	85	54	612	748	1310	190
4612	460	615	96	59	675	825	1440	170

Notes

1. Voltage at a current of 1 mA, after an impulse time of 50 ms with a rise time of 10 µs to 1 ms.
2. Measured with a standard impulse current 8/20 µs, defined in IEC 60-2 section 6, par. 16-I.
3. Derating, see Fig. 4.
4. Sinusoidal voltage assumed. For a non-sinusoidal voltage, the crest voltage x 0,707 should be used for type selection.
5. A current impulse of 8/20 µs (defined in IEC 60-2 section 6) is used as a standard for impulse current and clamping voltage ratings. The transient energy is given for one impulse applied during the life of the component. Figure 3 gives the derating for different numbers and longer duration of impulses. The shift of the varistor voltage does not exceed ± 5%.
6. High energy surges are generally of longer duration. The max. energy for 1 impulse 10/1000 µs is given as a reference for long duration impulses. This impulse can be characterized by peak current I_p and impulse width t_2 (virtual time to half I_p value, defined in IEC 60-2 section 6), see Fig. 5. If V_p is the clamping voltage corresponding to I_p, the energy absorbed in the VDR is determined by equation $E = K.V_p.I_p.t_2$; K depends on t_2. When t_1 is 8 to 10 µs and t_2 = 20 µs, K = 1; when t_2 = 50 µs, K = 1,2; when t_2 = 100 µs, K = 1,3; when t_2 = 1000 µs, K = 1,4.

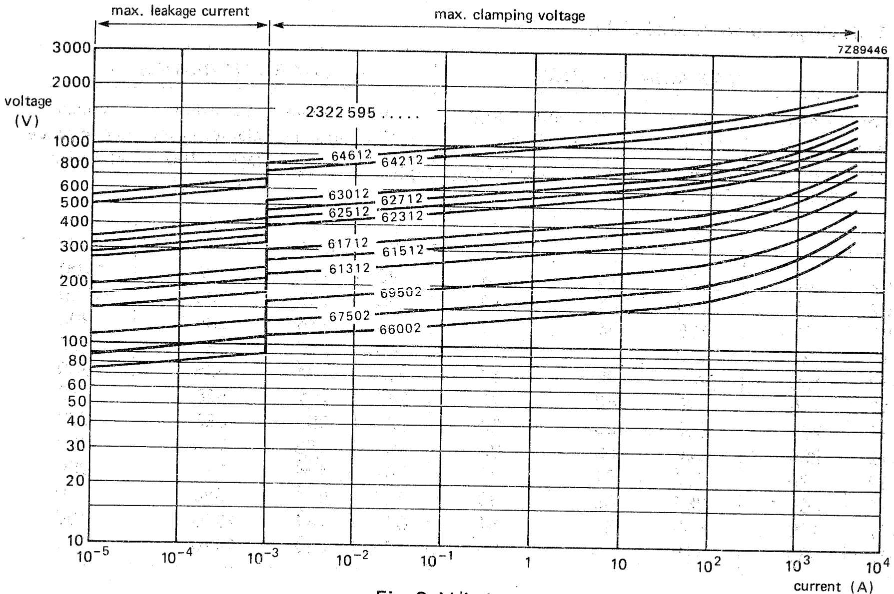


Fig. 2 V/I characteristics.

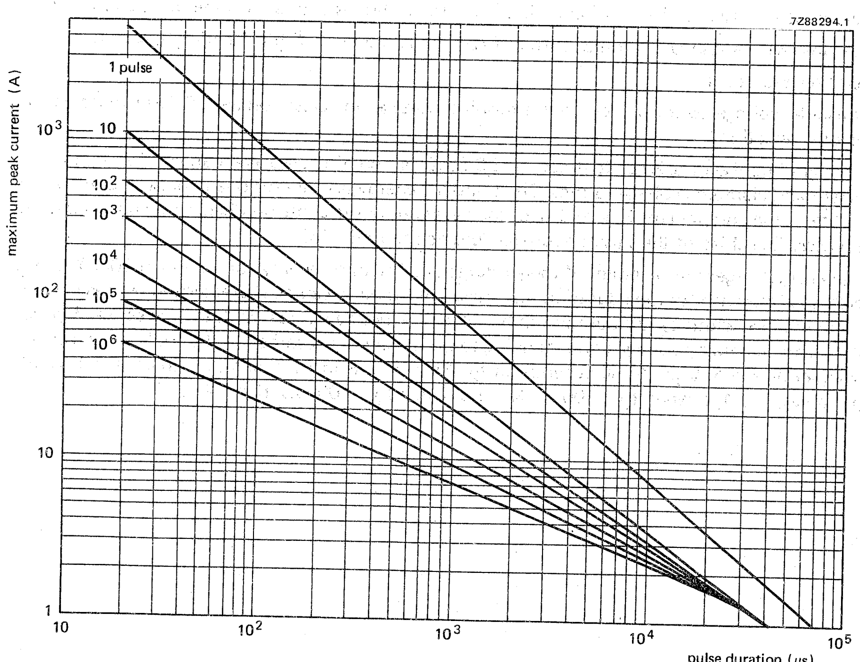


Fig. 3 Max. applicable transient current as a function of pulse duration.

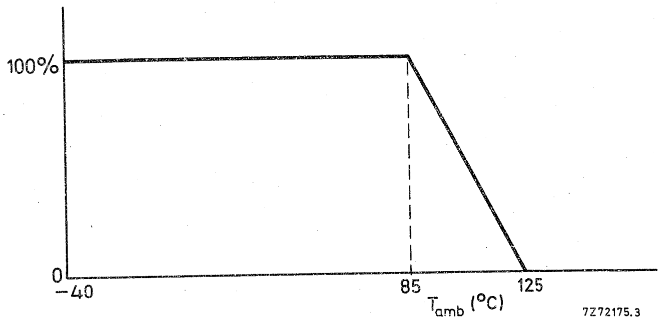


Fig. 4 Derating of max. d.c. and r.m.s. working voltage with temperature.

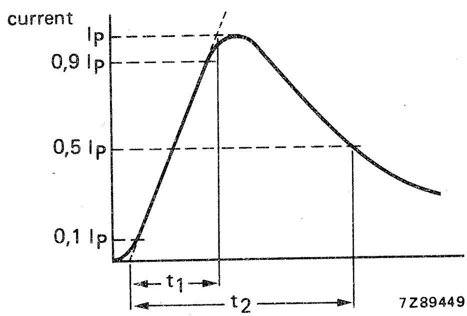


Fig. 5.

PACKAGING

The resistors 2322 594 6.... are supplied in bulk packing only in boxes of 250.

LIGHT DEPENDENT RESISTORS (LDR) B

GENERAL

Light dependent resistors (LDRs) are made from cadmium sulphide containing no or very few free electrons when not illuminated. Its resistance is then quite high. When it absorbs light, electrons are liberated and the conductivity of the material increases. Cadmium sulphide is therefore a photoconductor. The approximate relationship between the resistance and illumination is:

$$R = A.\ L^{-\alpha}$$

where: R = resistance in Ω
L = illumination in lux
A and α are constants.

The value of α depends on the cadmium sulphide used and on the manufacturing process. Values around 0,7 to 0,9 are quite common. The relationship between the resistance and the illumination is shown in the graph on the next page.

SPECTRAL RESPONSE

The resistors are only light dependent over a limited range of wavelengths. LDRs have their maximum response at about 680 nm.

TEMPERATURE DEPENDENCY

Electrons can be excited not only by photons but also by thermal agitation. The dark resistance is therefore not infinite at normal temperatures. It increases with the ambient temperature and can be decreased by cooling the device.

The temperature can also affect the resistance under illumination. At practical illumination levels and normal ambient temperatures the temperature coefficient is, however, very small and can be neglected.

RECOVERY RATE

When an LDR is brought from a certain illumination level into total darkness, the resistance does not increase immediately to the dark value. The recovery rate is specified in kΩ/s and for current LDR types it is more than 200 kΩ/s (during the first 20 seconds starting at a light level of 1,000 lux).

The recovery rate is much greater in the reverse direction, e.g. going from darkness to an illumination level of 300 lux, it takes less than 10 ms to reach a resistance which corresponds with a light level of 400 lux.

SURVEY

minimum dark resistance	light resistance	maximum dissipation at 40 °C	ambient temperature range	catalogue number
10 MΩ 1 MΩ 10 MΩ	75 to 300 Ω max. 110 Ω 75 to 300 Ω	0,1 W	−30 to + 60 °C	2322 600 93001 2322 600 93002 2322 600 94001
10 MΩ 10 MΩ 1 MΩ 10 MΩ 10 MΩ 10 MΩ	75 to 300 Ω max. 250 Ω max. 110 Ω max. 190 Ω 30 to 96 Ω 150 to 300 Ω	0,2 W	−20 to + 60 °C	2322 600 95001 2322 600 95003 2322 600 95006 2322 600 95007 2322 600 95008 2322 600 95009
Recovery rate			min. 200 kΩ/s	

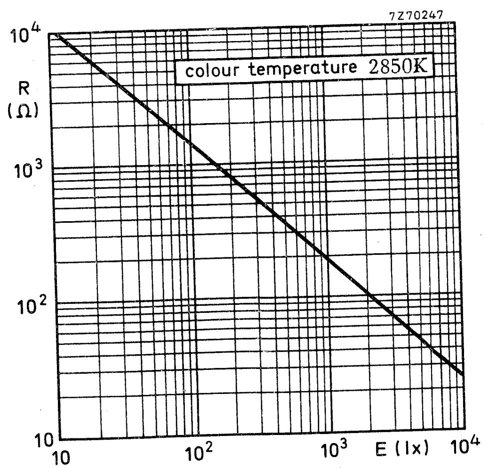
DESCRIPTION

Disc shaped resistors made of cadmium sulphide. They are sealed and have two solid tinned copper wires.

APPLICATION

LDRs are intended for non-critical on/off applications, in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power) e.g. in toys.

TYPICAL CHARACTERISTICS



Resistance as a function of illumination.

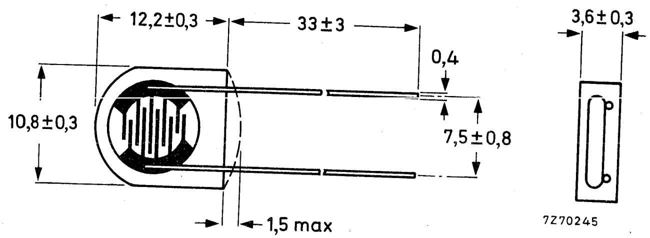
LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA

Dark resistance R_D	2322 600 93001	> 10 MΩ
	2322 600 93002	> 1 MΩ
Light resistance R_L	2322 600 93001	75 to 300 Ω
	2322 600 93002	< 110 Ω
Recovery rate		> 200 kΩ/s
Maximum dissipation at 40 °C		0,1 W
Ambient temperature range		−30 to + 60 °C

MECHANICAL DATA

Outline drawing



Marking

None

Mass

0,75 g approximately

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

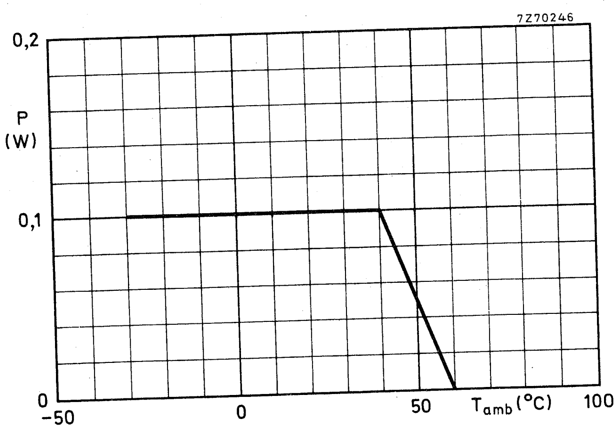
Tensile strength	5 N
Bending	2,5 N

Soldering

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

ELECTRICAL DATA

Dark resistance R_D	2322 600 93001	min. 10 MΩ
	2322 600 93002	min. 1 MΩ
Light resistance R_L	2322 600 93001	75 to 300 Ω
	2322 600 93002	max. 110 Ω
Recovery rate		min. 200 kΩ/s
Dissipation at 40 °C		max. 0,1 W
Capacitance at 1000 Hz		max. 8 pF
Repetitive peak voltage not exceeding max. dissipation		max. 150 V
Dielectric withstanding peak voltage between terminals and body		min. 200 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness		200 V
Operating ambient temperature range		−30 to + 60 °C



Permissible dissipation as a function of ambient temperature.

PACKAGING

100 per box

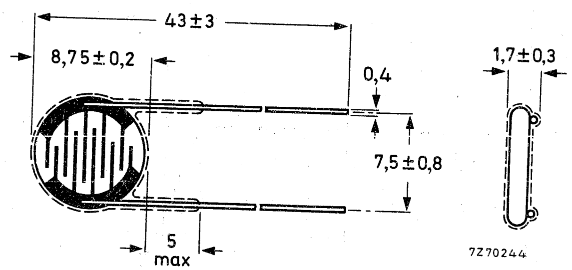
LIGHT DEPENDENT RESISTOR

QUICK REFERENCE DATA

Dark resistance R_D	> 10 MΩ
Light resistance R_L	75 to 300 Ω
Recovery rate	> 200 kΩ/s
Maximum dissipation at 40 °C	0,1 W
Ambient temperature range	–30 to + 60 °C

MECHANICAL DATA

Outline drawing



Marking

None

Mass

0,35 g approximately

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

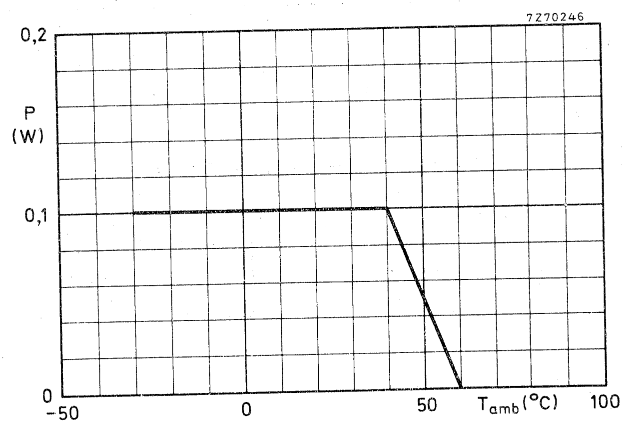
Tensile strength	5 N
Bending	2,5 N

Soldering

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

ELECTRICAL DATA

Dark resistance R_D	min. 10 MΩ
Light resistance R_L	75 to 300 Ω
Recovery rate	min. 200 kΩ/s
Dissipation at 40 °C	max. 0,1 W
Capacitance at 1000 Hz	max. 8 pF
Repetitive peak voltage, not exceeding max. dissipation	max. 150 V
Dielectric withstanding peak voltage between terminals and body	200 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness	200 V
Operating ambient temperature range	−30 to + 60 °C



Permissible dissipation as a function of ambient temperature.

PACKAGING

100 per box

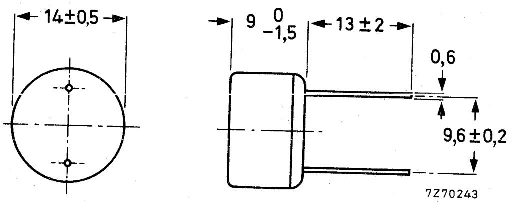
LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA

Dark resistance R_D	> 10 MΩ 2322 600 95006 > 1 MΩ
Light resistance R_L	30 to 300 Ω
Recovery rate	> 200 kΩ/s
Maximum dissipation at 40 °C	0,2 W
Ambient temperature range	−20 to + 60 °C

MECHANICAL DATA

Outline drawing



Marking

Year and month of production is printed on the body in yellow.

Mass

1,3 g approximately.

Mounting

In any position by soldering the leads at least 10 mm from the body.

Robustness of terminations

Tensile strength	10 N
Bensing	5 N

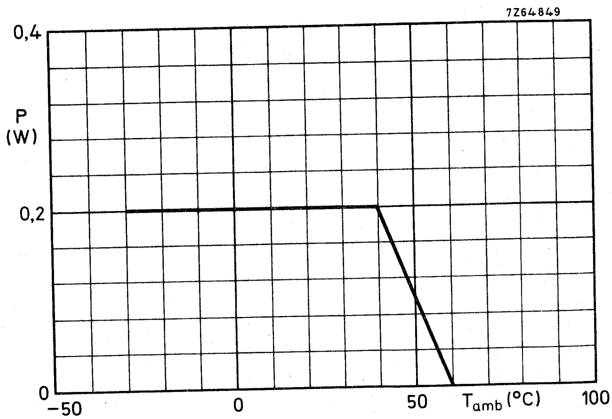
Soldering

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

ELECTRICAL DATA

catalogue number	resistance dark value R_D	resistance light value R_L
2322 600 95001	min. 10 MΩ	75 to 300 Ω
95003	min. 10 MΩ	max. 250 Ω
95006	min. 1 MΩ	max. 110 Ω
95007	min. 10 MΩ	max. 190 Ω
95008	min. 10 MΩ	30 to 96 Ω
95009	min. 10 MΩ	150 to 300 Ω

Recovery rate	min. 200 kΩ/s
Dissipation at 40 °C	max. 0,2 W
Capacitance at 1000 Hz	max. 6 pF
Repetitive peak voltage not exceeding max. dissipation	max. 110 V
Dielectric withstanding peak voltage between terminals and case	150 V
Dielectric d.c. test voltage between terminals for 1 s in total darkness	150 V
Operating ambient temperature range	–20 to + 60 °C



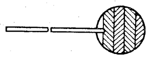
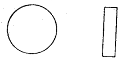
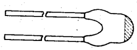
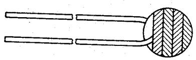
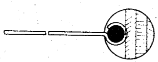
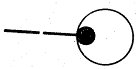
Permissible dissipation as a function of ambient temperature.

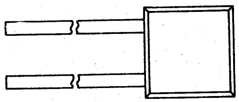
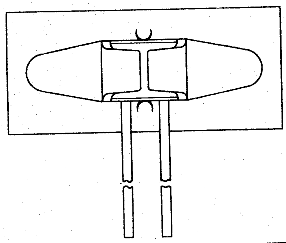
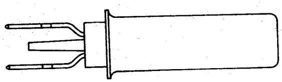
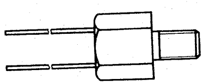
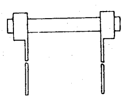
PACKAGING

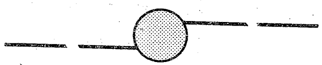
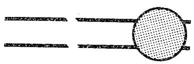
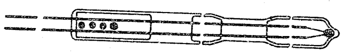
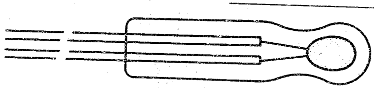
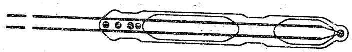
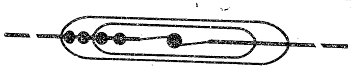
500 per box

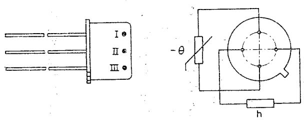
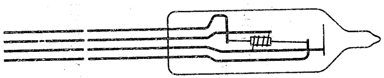
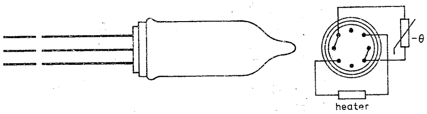
NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC) C

SURVEY

type	P_{max} W	temp. range at zero power °C	$B_{25/85}$-value ±5% K	R_{25} Ω	catalogue number
DISC 	1	−25 to +125	2600 to 5450	1,1 to 1300	2322 610 1....
		25 to +100 −25 to +155	2975	270 to 2200 5	2322 611 2322 644 90012
	0,25 0,25	−25 to +125 −55 to +85	3660 to 4150 4000	2,7 k to 330 k R_{-30} = 50000 R_{-10} = 15000 R_{-10} = 15000 R_{+25} = 2700	2322 640 1.... 2322 640 90012 2322 640 90014
	0,5	−25 to +125	2675 to 4800	3,3 to 470 k	2322 642 6....
	1 1,5	−25 to +125	3500 to 4300	150 to 4700	2322 643 2322 644
		−25 to +155	4650 3350	82 min. 15	2322 644 90004 90005

moulded 	0,25	−55 to +85	4000	R_{-30} = 50000 R_{-10} = 15000	2322 640 90013 98013
	0,25	−55 to +85	4000	R_{-10} = 15000 R_{-25} = 2700	2322 640 90015 98015
	0,25	−10 to +125	3750	R_{+25} = 12000 R_{+100} = 950	2322 640 90004 98004
	0,25	−25 to +200	4300	R_{+100} = 16700 R_{+200} = 1120	2322 640 90005 98005
in special housing 	0,25	−25 to +110	3720	R_{+25} = 12 k R_{+90} = 1300	2322 640 90007 90021
	0,5	−25 to +100	2675 to 4750	3,3 to 330 k	2322 642 2....
ROD 	0,6 1,5 2,3	−25 to 155	3300 to 4300 3250 to 4150 3200 to 4200	4,7 k to 470 k 4,7 k to 150 k 4,7 k to 150 k	2322 635 0.... 2322 636 0.... 2322 637 0....

type	P_{max} W	temp. range at zero power °C	$B_{25/85}$-value ±5% K	R_{25} Ω	catalogue number
MINIATURE BEAD  		−25 to +200	2200 to 4100	680 to 680 k	2422 634 0.... 2322 634 1....
glass encapsulated 	0,1	−25 to +200	2200 to 4100	680 to 680 k	2322 627 1....
	0,1	−25 to +200	2200 to 4100	680 to 680 k	2322 627 2....
	0,1	−55 to +300	3800 to 4200	100 k to 1 M	2322 627 3.....
	0,1	−25 to +200	2200 to 4100	680 to 680 k	2322 627 4....
	0,06	−25 to +200	2200 to 4100	680 to 680 k	2322 634 2....

INDIRECTLY HEATED					
	0,065	−25 to +200	2750 3980	3,3 k 330 k	2322 628 31332 2322 628 31334
 *	0,025 0,025 0,015	−25 to +200 −25 to +85 −25 to +85	3100 3330 3860	500 – 750 1200 35 to 15 k	2322 628 90014 2322 628 90015 2322 628 90017
	0,015	−25 to +85	3860	55 to 15 k	2322 628 90016

* Detailed information available on request.

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.

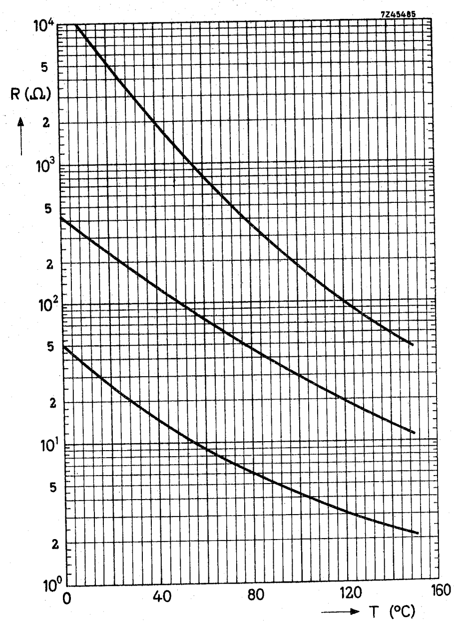


Fig. 1.

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.

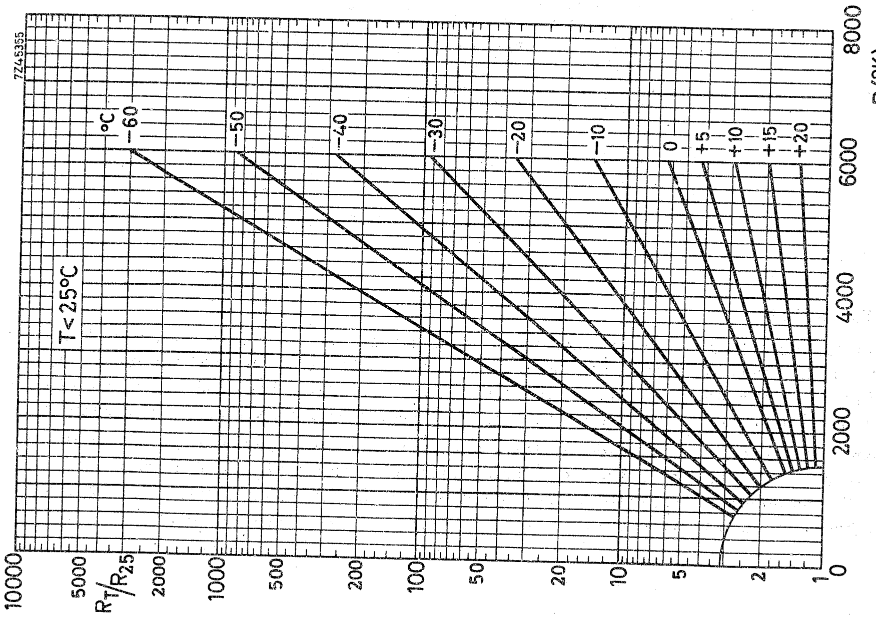


Fig. 2 R_T/R_{25} as a function of B-value with temperature as a parameter.

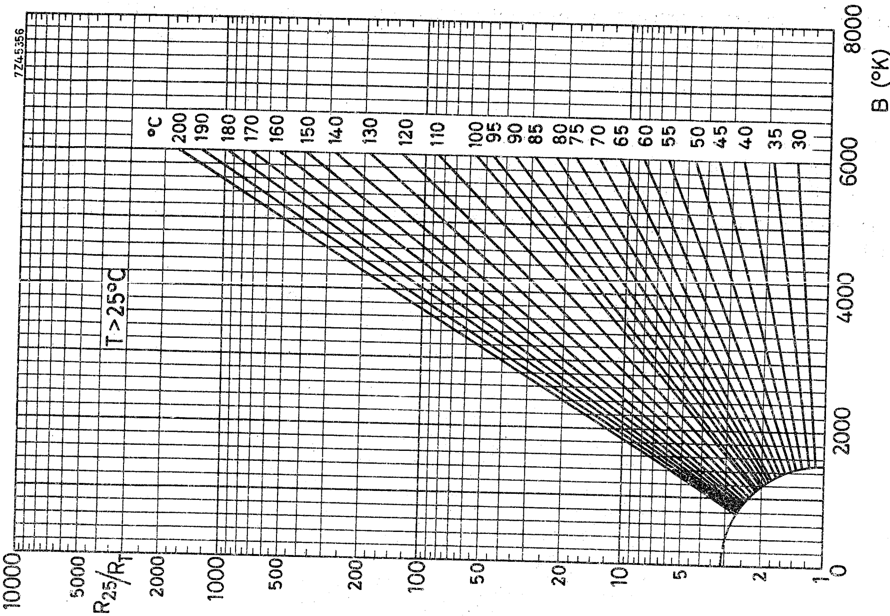


Fig. 3 R_{25}/R_T as a function of B-value with temperature as a parameter.

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:

$R_1 = Ae^{B/T_1}$ 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.

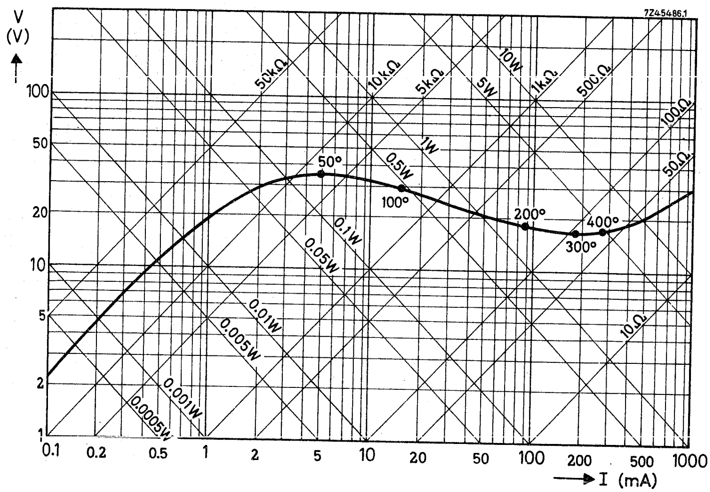


Fig. 4 Voltage versus current characteristics of an NTC thermistor.

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:

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

In case of equilibrium

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

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 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:

$$-H dT = \delta\,(T-T_o)\,dt \qquad (13)$$

in which T_o is the ambient temperature.

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

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:

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

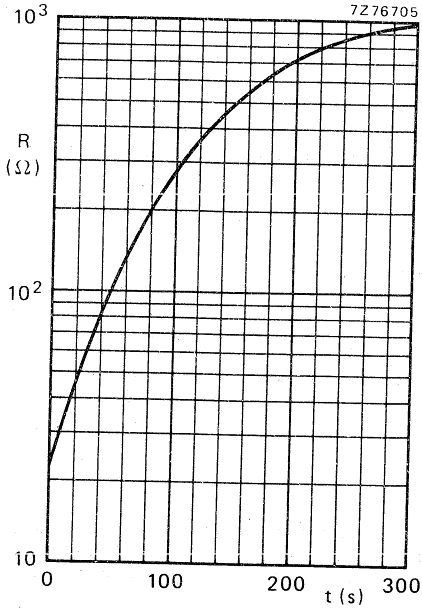


Fig. 5 Variation of resistance with time under normal cooling conditions of a rod type NTC. Ambient temperature 25 °C.

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).

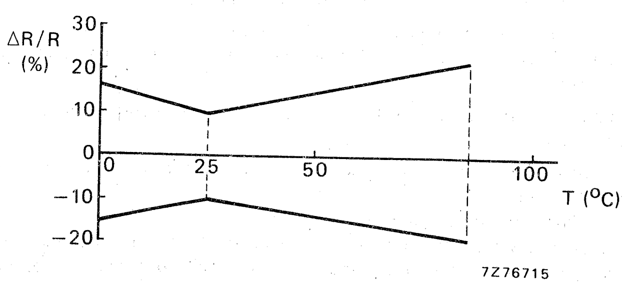


Fig. 6.

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.

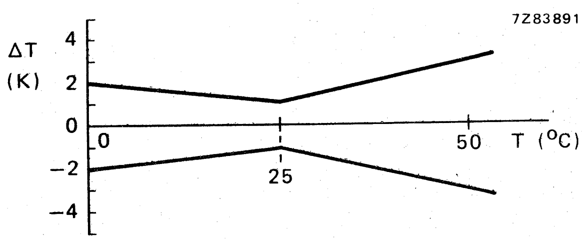


Fig. 7.

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.

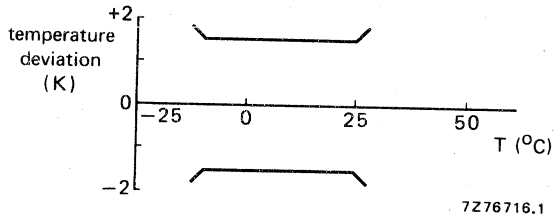


Fig. 8.

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 THERMISTOR RESISTANCE

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

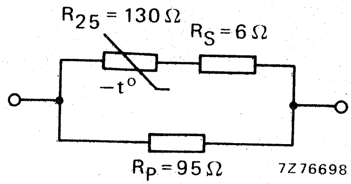


Fig. 9 NTC thermistor/resistor combination to change the R/T characteristic.

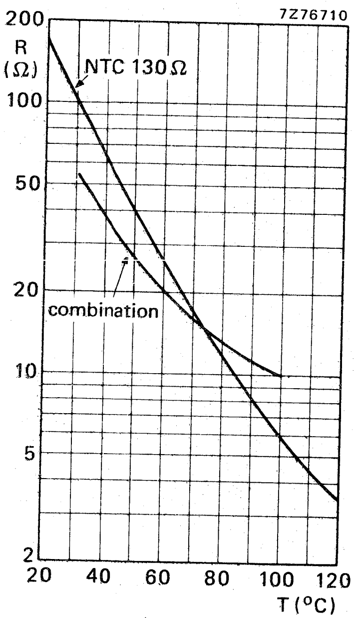


Fig. 10 Resistance as a function of temperature for the circuit of Fig. 7.

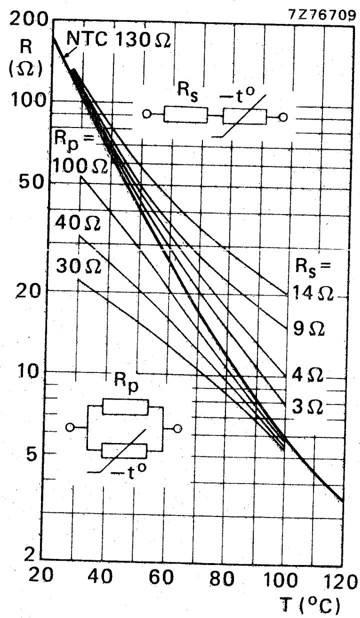


Fig. 11 Resistance as a function of temperature with the values of series and parallel resistors as parameters.

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

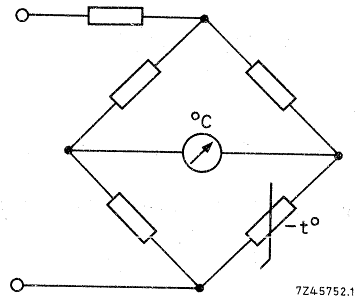
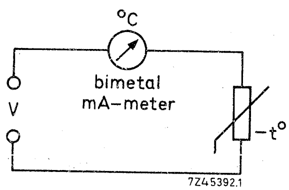


Fig. 12 Temperature measurement in industrial and medical thermometers.



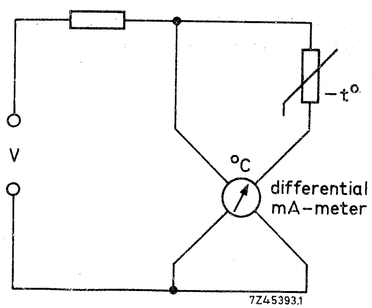


Fig. 13
Temperature measurement in cars. Cooling water measurements with bimetal or differential milliammeters.

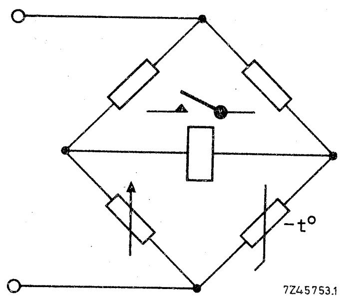


Fig. 14
Temperature control with a bridge incorporating an NTC thermistor and a relay or a static switching device.

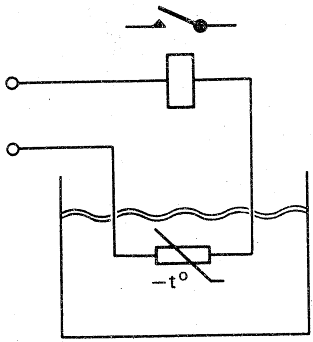


Fig. 15 Liquid level control.

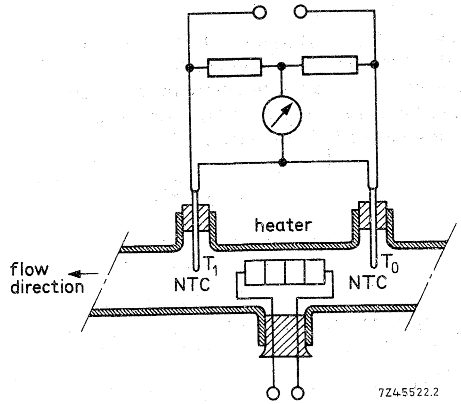
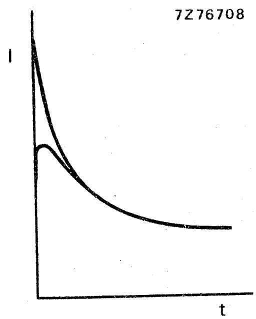
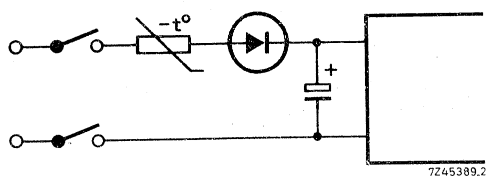


Fig. 16
Flow measurement of liquids. The temperature difference between T_1 and T_0 is a measure for the velocity of the fluid.





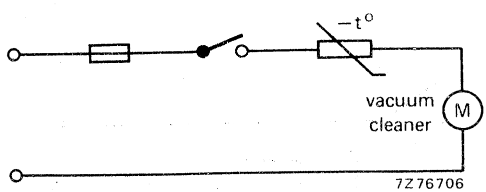
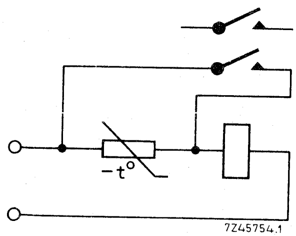


Fig. 17
Inrush current limiter, e.g. for protection of Si-diodes, fuses and switches.

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.



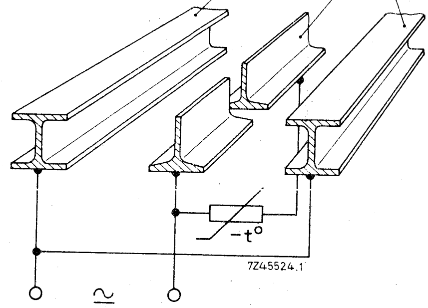


Fig. 19
Model trains. As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

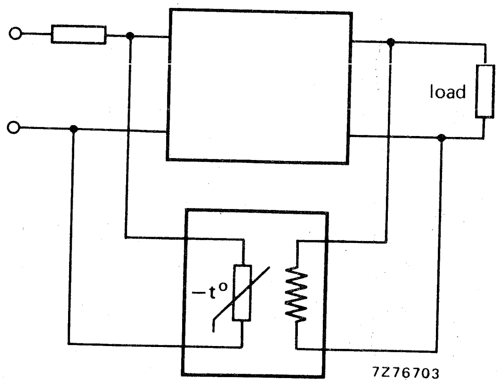


Fig. 20
Gain compensation or gain control with an indirectly heated NTC.

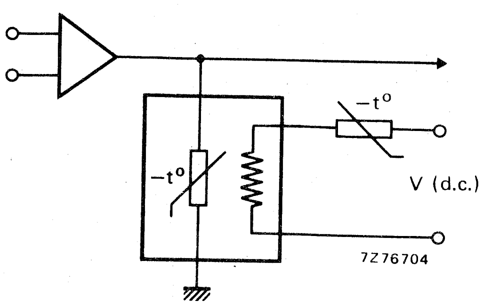


Fig. 21
Compensation for the influence of ambient temperature variations in an h.f. amplifier.

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

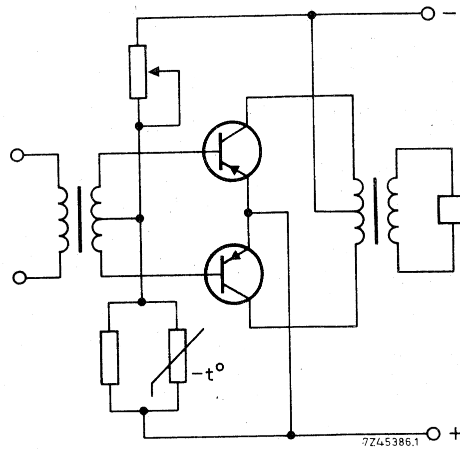


Fig. 23
Transformerless audio output stage with temperature compensation.

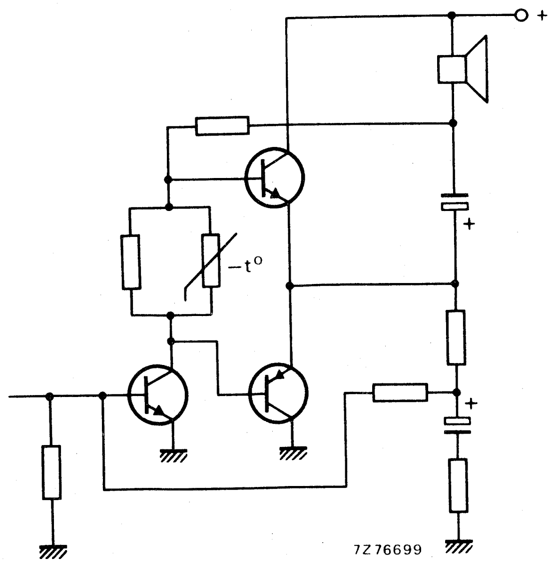


Fig. 24
Stabilization with temperature of an a.g.c. amplifier in a television set.

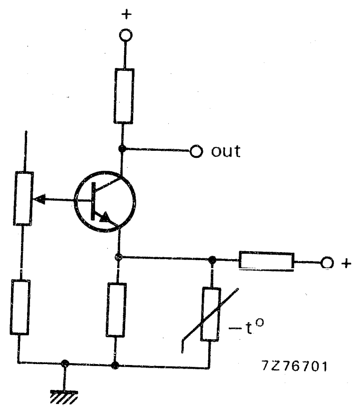
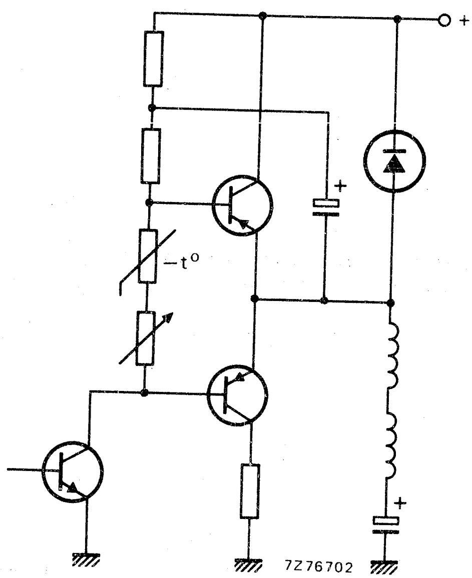


Fig. 25
Compensation of drift in field deflection coils. The influence of the positive temperature coefficient of the copper windings is compensated by means of an NTC thermistor.



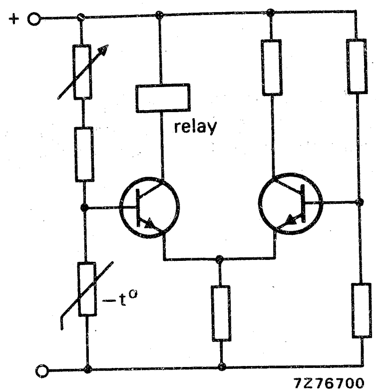


Fig. 26 Simple thermostat.

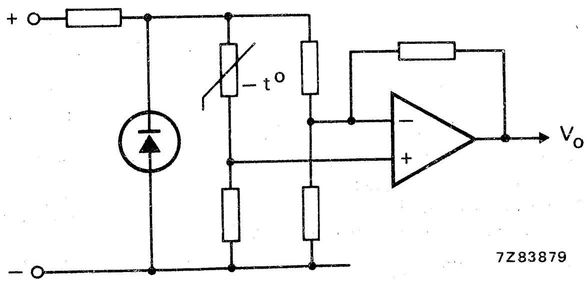


Fig. 27 Temperature sensing bridge with amplifier. The op-amp acts as difference amplifier. The sensitivity can be very high.

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.

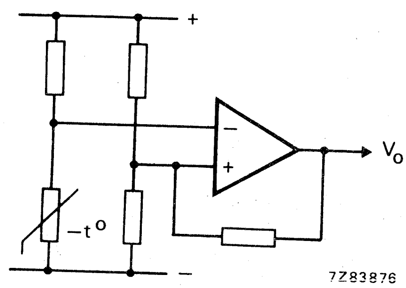


Fig. 29.

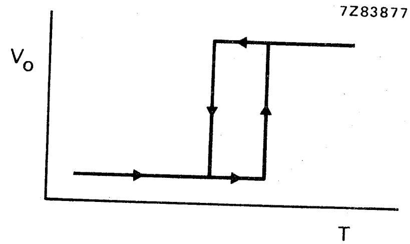


Fig. 30 Temperature controlled oscillator. This is a simple interface circuit for digital and microcomputer-controlled systems. The frequency of the output pulses is proportional to the temperature of the NTC thermistor. See Fig. 31.

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

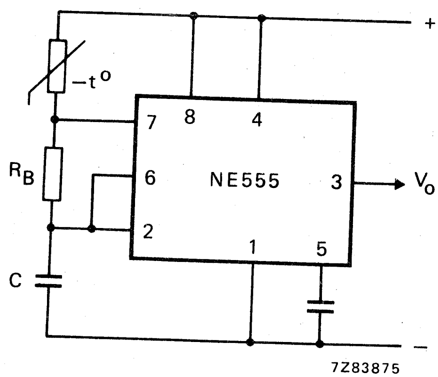
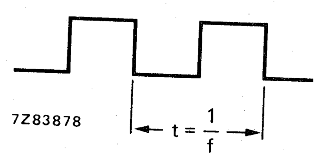


Fig. 31.



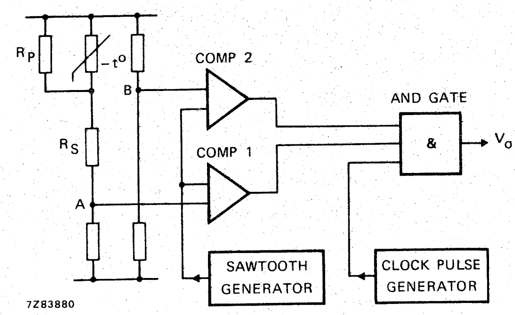


Fig. 32 Temperature sensing bridge with 0 °C offset and analogue to digital conversion. Due to R_p and R_s the voltage at point A varies linearly with the temperature of the NTC thermistor. The voltage at point B is equal to the voltage at point A when the temperature of the NTC thermistor is 0 °C. Both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

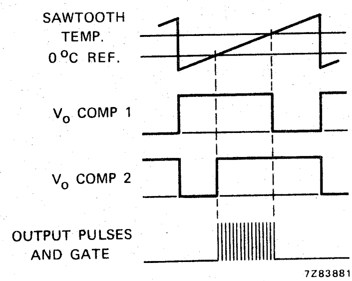
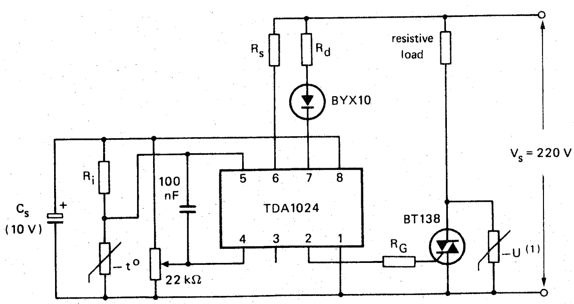


Fig. 33.



(1) spike suppressor (zinc-oxide VDR, type 2322 594 72512)

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	1,1 to 1300 Ω
$B_{25/85}$-value	2600 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

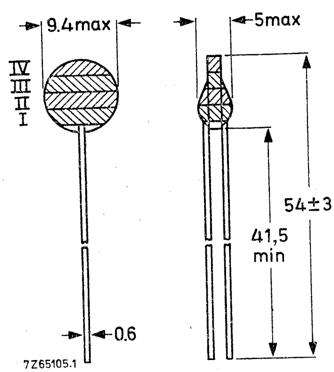


Fig. 1.

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
2118	1118	1,1	2600	–2,90	brown	brown	gold
2228	1228	2,2	2675	–3,00	red	red	gold
2408	1408	4	2800	–3,15	yellow	black	gold
2608	1608	6	2825	–3,15	blue	black	gold
2808	1808	8	2900	–3,25	grey	black	gold
2109	1109	10	2950	–3,30	brown	black	black
2129	1129	12	3050	–3,40	brown	red	black
2159	1159	15	3125	–3,50	brown	green	black
2339	1339	33	3250	–3,65	orange	orange	black
2509	1509	50	3300	–3,70	green	black	black
2829	1829	82	4400	–4,95	grey	red	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

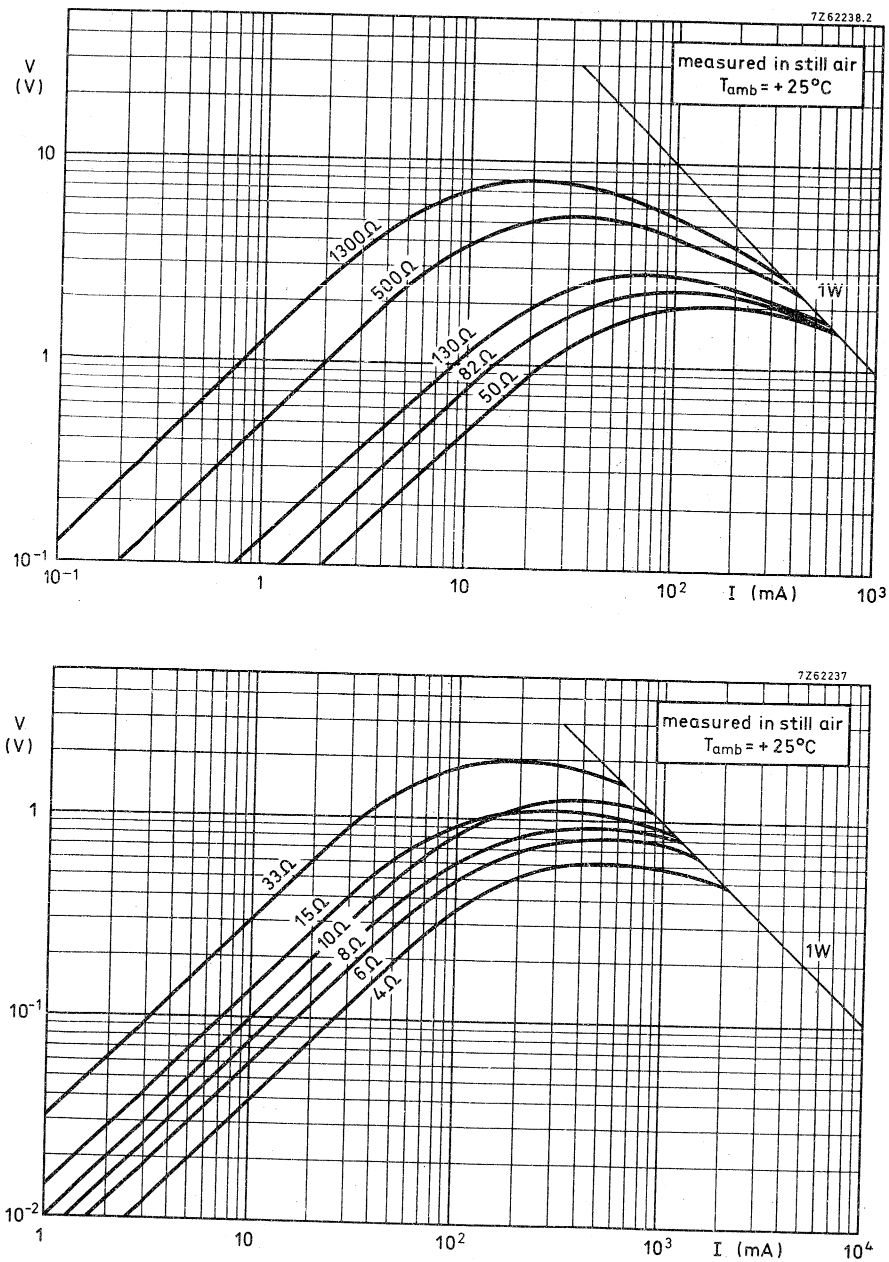


Fig. 2a and b Typical voltage/current characteristics.

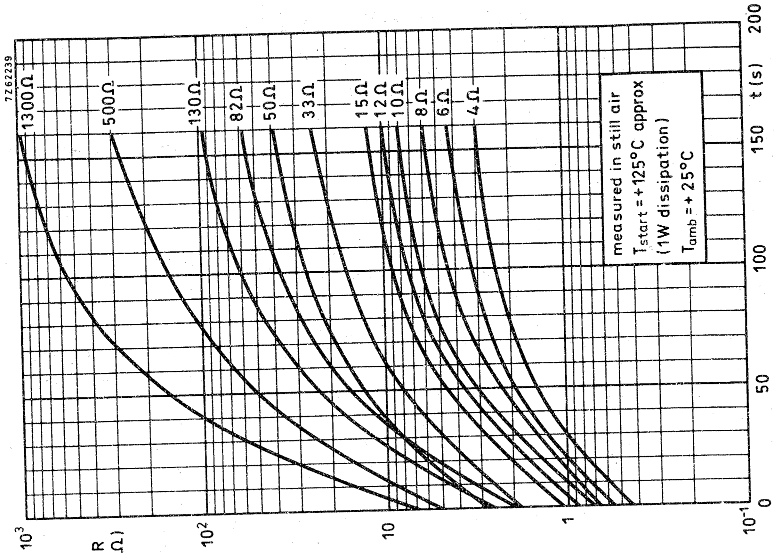


Fig. 4 Typical resistance/time (cooling) characteristics.

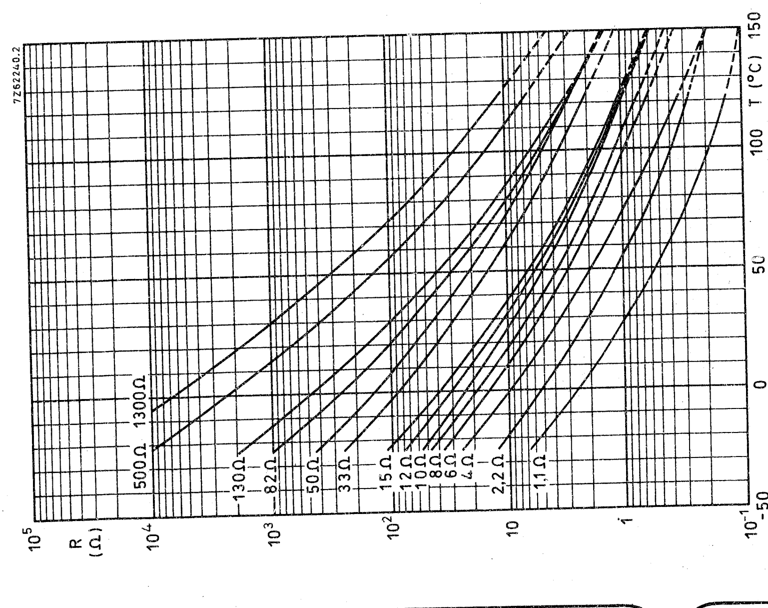


Fig. 3 Typical resistance/temperature characteristics.

NTC THERMISTORS
for motor cars

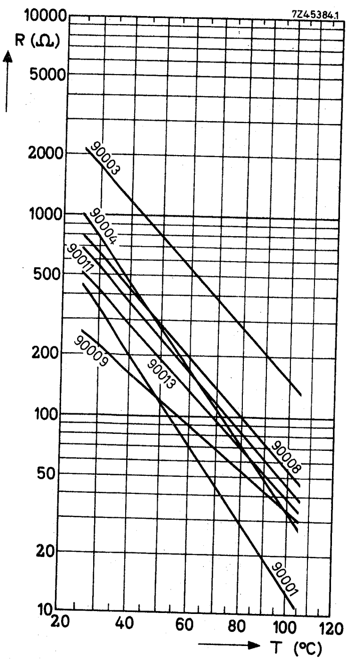
APPLICATION

For temperature sensors 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 (40 to 50 °C) and at a higher temperature (96,5 to 100 °C), so that a high accuracy at the working temperature is obtained (two-point sensor).

R_{25} Ω	R_{40} Ω	R_{50} Ω	$R_{96,5}$ Ω	R_{100} Ω	diameter mm	catalogue number
2200	1030-1310		147-173		7,0 ± 0,3	2322 611 90003
500		175 -215		35 -43	6,9 ± 0,2	90013
500		92,5-134		12 -15	6,9 ± 0,2	90001
1000		221,5-318,5		30 -36	6,9 ± 0,2	90004
270		97 -143		29,5-36,5	6,9 ± 0,2	90009
700		207 -264		41,4-48,6	6,9 ± 0,2	90011
800		244 -315		48,0-58,6	6,9 ± 0,2	90008



Resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4100 K
Maximum dissipation	100 mW
Dissipation factor	0,7 mW/K
Thermal time constant	14 s
Operating temperature range	
at zero power	−25 to + 200 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose, e.g. temperature measurement.

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two tinned dumet (CuNiFe) wires. It is resistant to cleaning solvents.

MECHANICAL DATA

Outlines

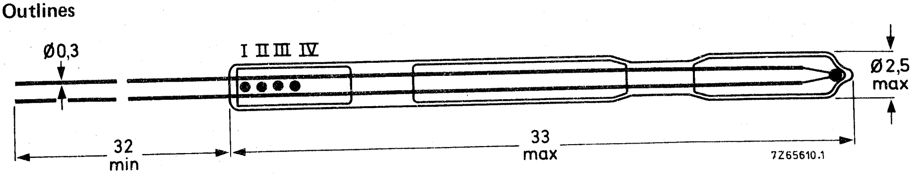


Fig. 1 Maximum bow in the centre of the glass envelope is 1 mm.

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

Mass
0,3 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.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

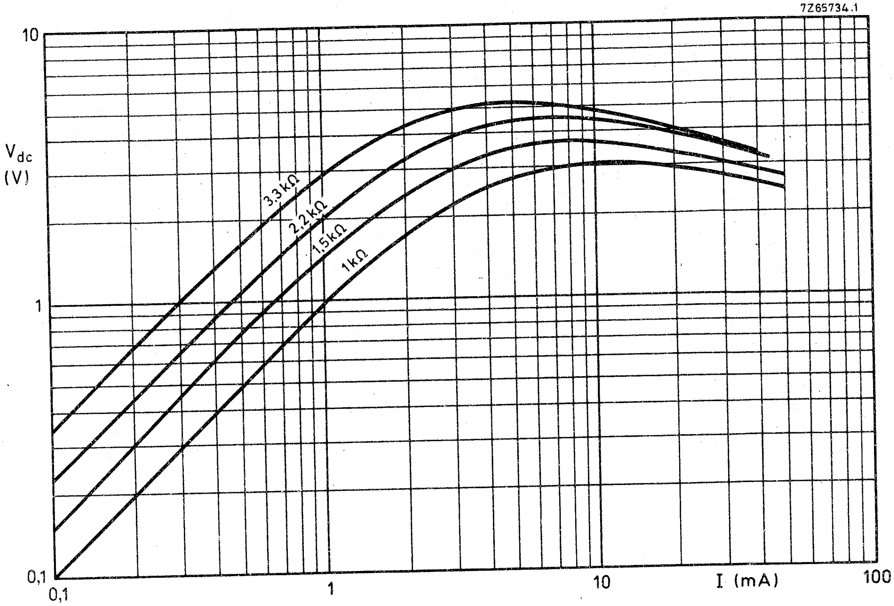
Unless otherwise specified, measured according to IEC publication 539.

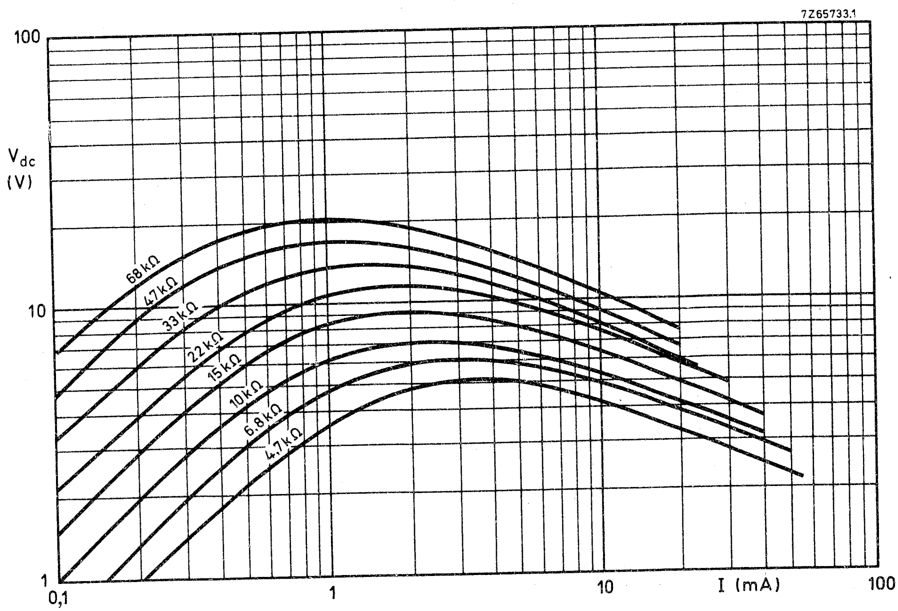
Table 1 Catalogue number 2322 627 4.....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code *		
tol. ± 5%*	tol. ± 10%	Ω	K	%/K	I	II	III
3681	2681	680	2200	–2,5	blue	grey	brown
3102	2102	1000	2375	–2,7	brown	black	red
3152	2152	1500	2500	–2,8	brown	green	red
3222	2222	2200	2600	–2,9	red	red	red
3332	2332	3300	2750	–3,1	orange	orange	red
3472	2472	4700	3725	–4,2	yellow	violet	red
3682	2682	6800	3775	–4,3	blue	grey	red
3103	2103	10 000	3875	–4,3	brown	black	orange
3153	2153	15 000	3800	–4,3	brown	green	orange
3223	2223	22 000	3850	–4,3	red	red	orange
3333	2333	33 000	3800	–4,3	orange	orange	orange
3473	2473	47 000	3850	–4,3	yellow	violet	orange
3683	2683	68 000	3900	–4,4	blue	grey	orange
3104	2104	100 000	3800	–4,3	brown	black	yellow
3154	2154	150 000	3880	–4,4	brown	green	yellow
3224	2224	220 000	3920	–4,4	red	red	yellow
3334	2334	330 000	3980	–4,5	orange	orange	yellow
3474	2474	470 000	4030	–4,5	yellow	violet	yellow
3684	2684	680 000	4100	–4,6	blue	grey	yellow

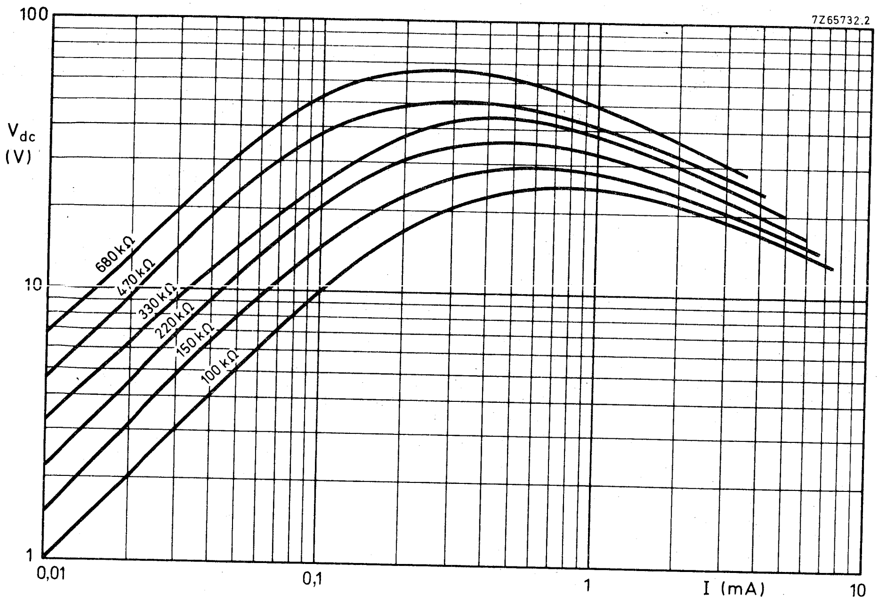
* Thermistors with 5% tolerance have a gold dot IV; 10% tolerance is identified by a silver dot IV (Fig. 1).

Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/K approx.
Thermal time constant	14 s approx.
Heat capacity	
of ceramic	$0{,}5 \cdot 10^{-3}$ J/K approx.
of complete component	$9{,}8 \cdot 10^{-3}$ J/K approx.
Operating temperature range	
at zero power	–25 to +200 °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

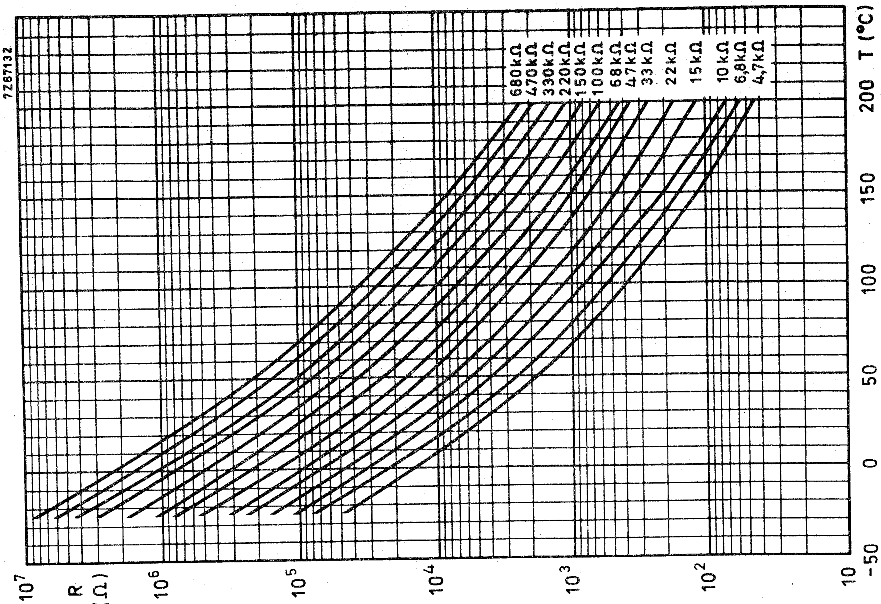


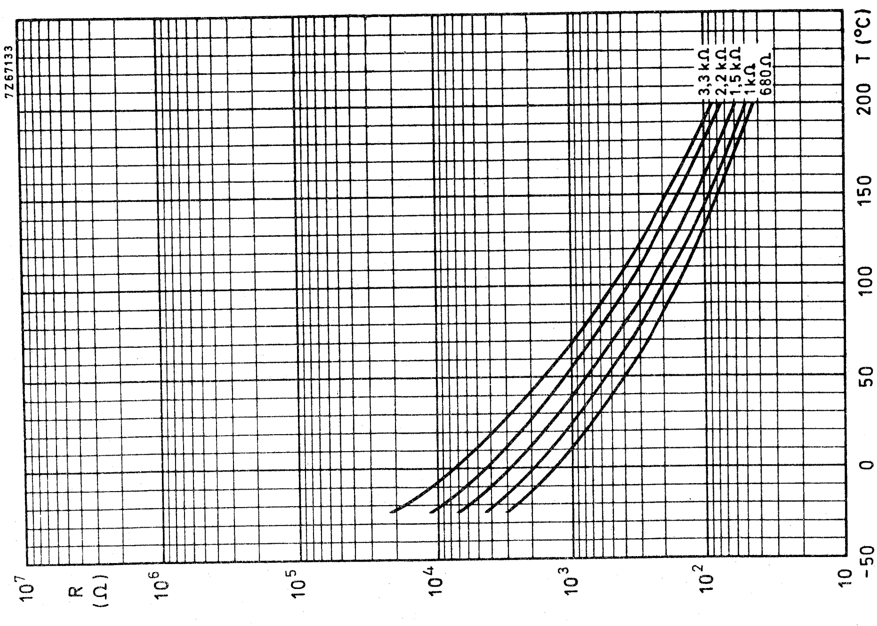


Typical voltage/current characteristics.



Typical voltage/current characteristics.





Typical resistance/temperature characteristics.

NTC THERMISTORS
miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4100 K
Maximum dissipation	100 mW
Dissipation factor	0,7 mW/K
Thermal time constant	10 s
Operating temperature range	
at zero power	−25 to + 200 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose, e.g. temperature measurement.

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two tinned dumet (CuNiFe) wires. It is resistant to cleaning solvents.

MECHANICAL DATA

Outlines

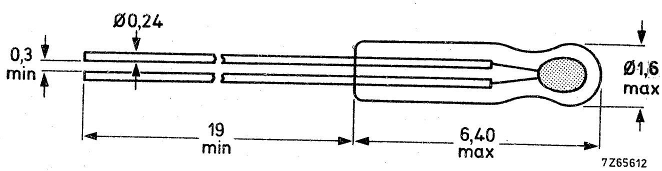


Fig. 1.

Marking
None

Mass
0,03 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

PACKAGING

100 thermistors in a cardboard box.

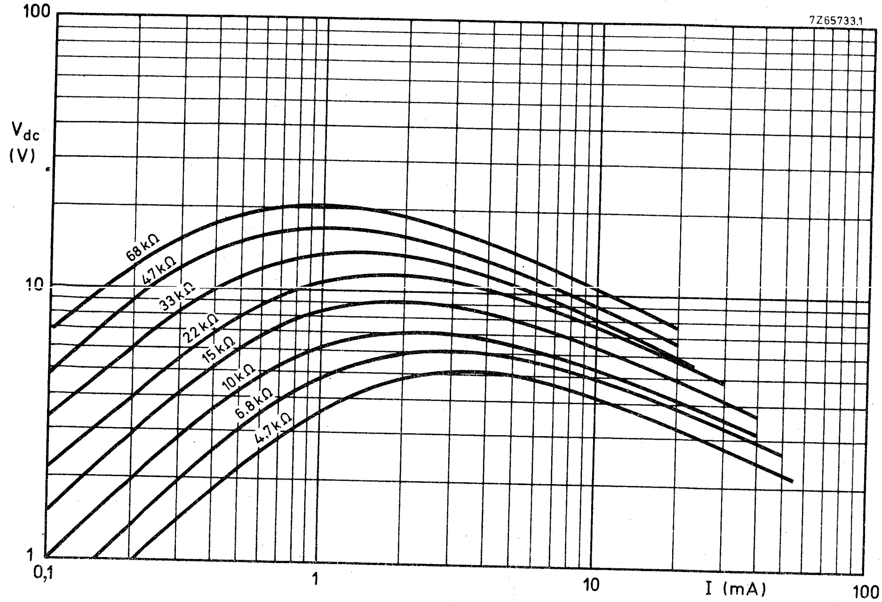
ELECTRICAL DATA

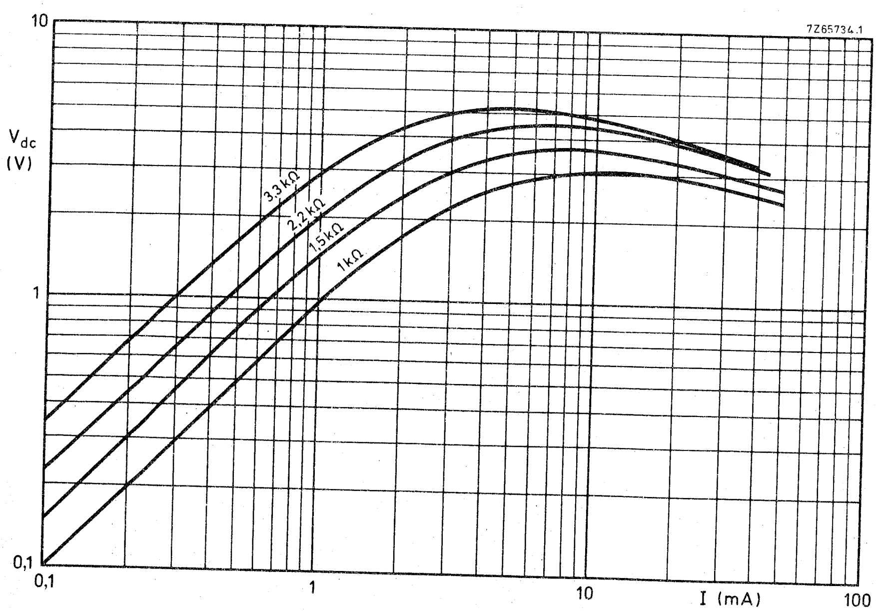
Unless otherwise specified, measured according to IEC publication 539.

Table 1 Catalogue number 2322 627 2.....

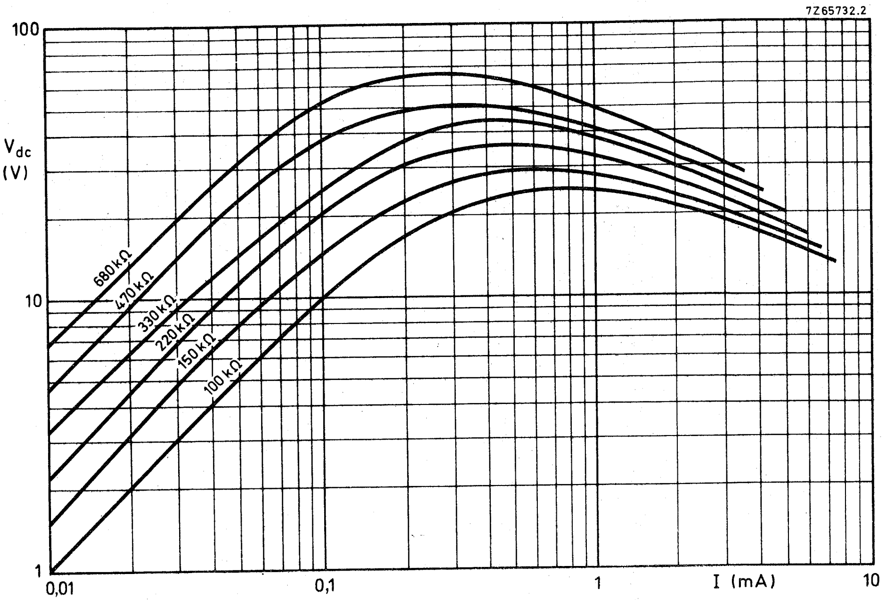
suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C
tol. ± 5%	tol. ± 10%	Ω	K	%/K
3681	2681	680	2200	−2,5
3102	2102	1000	2375	−2,7
3152	2152	1500	2500	−2,8
3222	2222	2200	2600	−2,9
3332	2332	3300	2750	−3,1
3472	2472	4700	3725	−4,2
3682	2682	6800	3775	−4,3
3103	2103	10 000	3875	−4,3
3153	2153	15 000	3800	−4,3
3223	2223	22 000	3850	−4,3
3333	2333	33 000	3800	−4,3
3473	2473	47 000	3850	−4,3
3683	2683	68 000	3900	−4,4
3104	2104	100 000	3800	−4,3
3154	2154	150 000	3880	−4,4
3224	2224	220 000	3920	−4,4
3334	2334	330 000	3980	−4,5
3474	2474	470 000	4030	−4,5
3684	2684	680 000	4100	−4,6

Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/K approx.
Thermal time constant	10 s approx.
Heat capacity	
of ceramic	$0{,}5 \cdot 10^{-3}$ J/K approx.
of complete component	$7{,}0 \cdot 10^{-3}$ J/K approx.
Operating temperature range	
at zero power	−25 to +200 °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

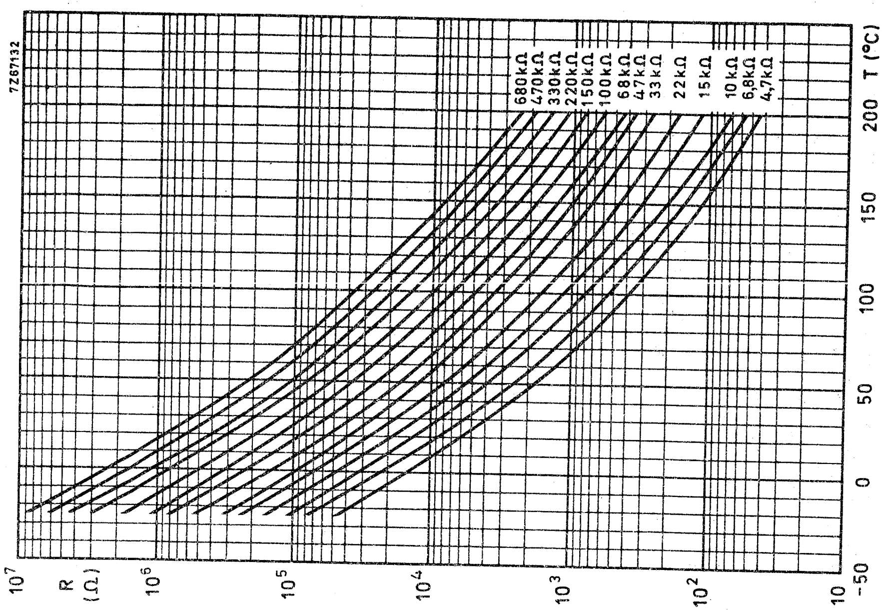


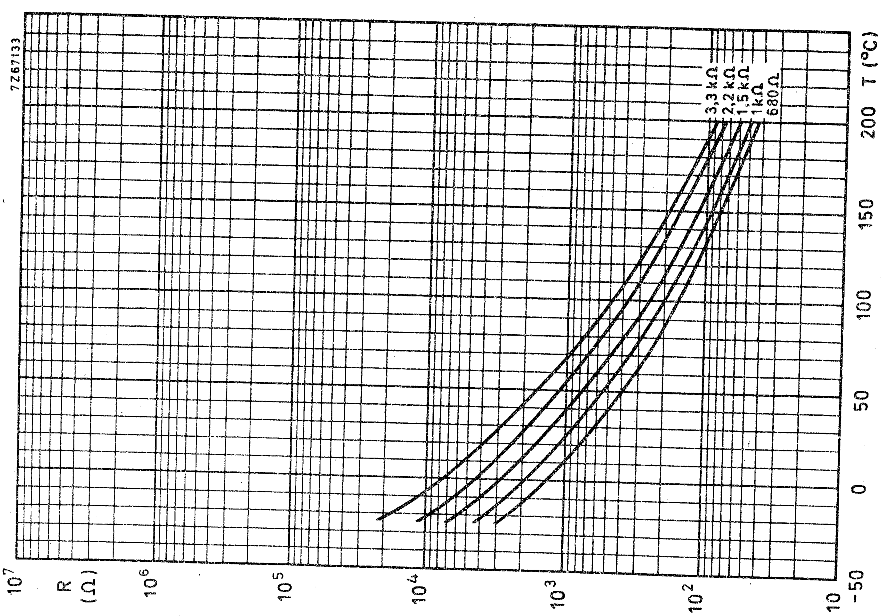


Typical voltage/current characteristics.



Typical voltage/current characteristics.





Typical resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	100 kΩ to 1 MΩ (E6 series)
$B_{25/85}$-value	3800 to 4200 K
Maximum dissipation	0,1 W
Dissipation factor	0,95 mW/K
Thermal time constant	18 s
Operating temperature range	
at zero power	−55 to + 300 °C
at maximum power	0 to + 55 °C

APPLICATION

For high temperature control.

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two dumet (CuNiFe) wires. It is resistant against cleaning solvents.

MECHANICAL DATA

Outlines

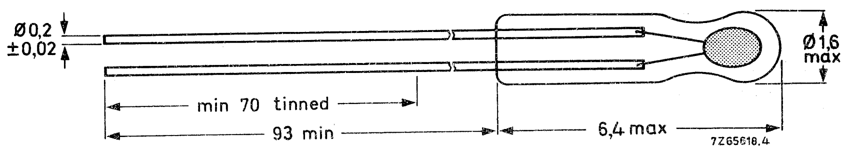


Fig. 1.

Marking
None

Mass
0,09 g approximately.

Mounting
In any position by soldering or clamping.

Soldering

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

Inflammability
Uninflammable

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

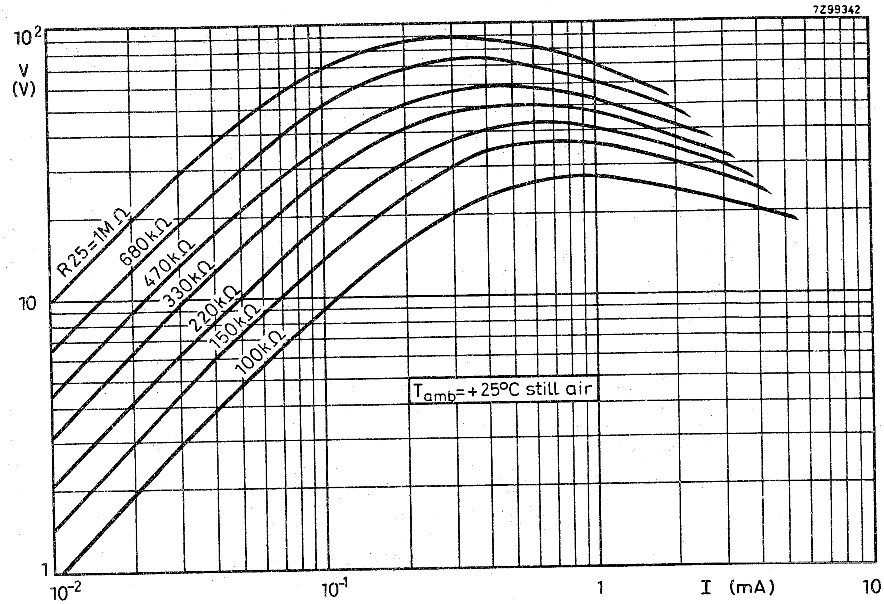
Unless otherwise specified, measured according to IEC publication 539.

Table 1 Catalogue number 2322 627 3.....

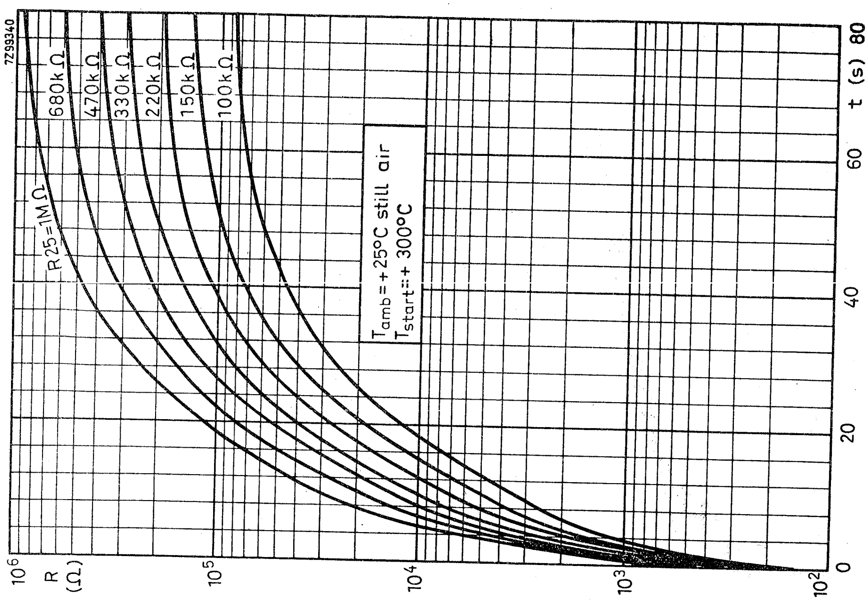
suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C
tol. ± 5%	tol. ± 10%	Ω	K	%/K
3104	2104	100 000	3800	–4,3
3154	2154	150 000	3880	–4,3
3224	2224	220 000	3920	–4,4
3334	2334	330 000	3980	–4,4
3474	2474	470 000	4030	–4,5
3684	2684	680 000	4100	–4,6
3105	2105	1000 000	4200	–4,7

Maximum dissipation at + 55 °C	0,1 W
Dissipation fator *	0,95 mW/K approx.
Thermal time constant *	18 s approx.
Heat capacity *	0,017 J/K approx.
Response time	1 s
Operating temperature range	
at zero power	–55 to + 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

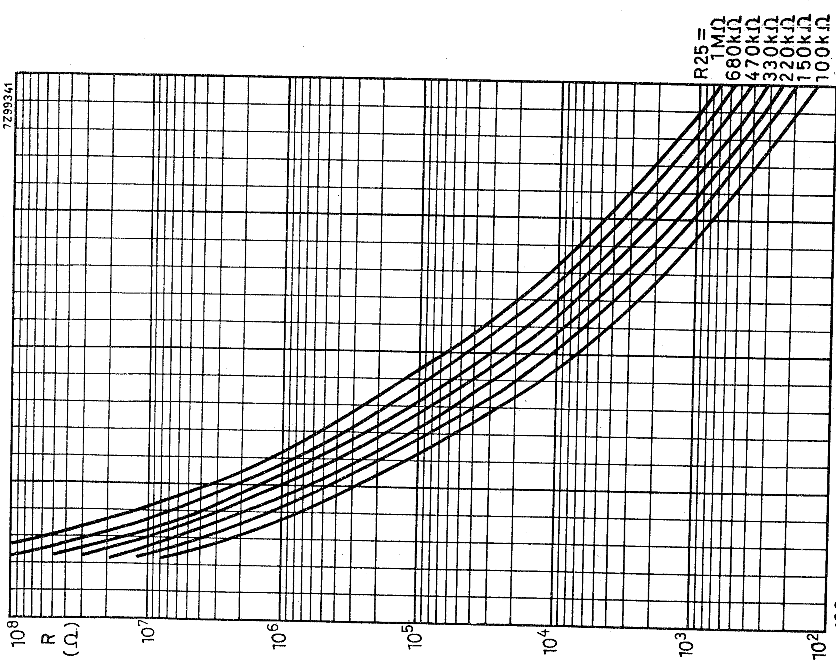
* Measurement made with specimen in phosphor-bronze clips, in still air.



Typical voltage/current characteristics.



Typical resistance/time (cooling) characteristics.



Typical resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at +25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4100 K
Maximum dissipation	100 mW
Dissipation factor	0,6 mW/K
Thermal time constant	9,5 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	−25 to +55 °C

APPLICATION

General purpose.

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two solid tinned dumet (CuNiFe) wires. It is resistant against cleaning solvents.

MECHANICAL DATA

Outlines

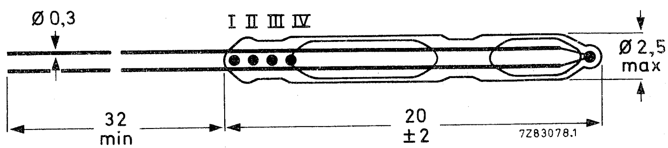


Fig. 1.

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

Mass
0,2 g approx.

Mounting
In any position by soldering.

Robustness of terminations

Tensile strength	2,5 N
Bending	1,25 N

PACKAGING

100 thermistors in a cardboard box.

Soldering

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

Inflammability

Uninflammable

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Table 1 Catalogue number 2322 627 4.....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code *		
tol. ± 5%	tol. ± 10%	Ω	K	%/K	I	II	III
3681	2681	680	2200	–2,5	blue	grey	brown
3102	2102	1000	2375	–2,7	brown	black	red
3152	2152	1500	2500	–2,8	brown	green	red
3222	2222	2200	2600	–2,9	red	red	red
3332	2332	3300	2750	–3,1	orange	orange	red
3472	2472	4700	3725	–4,2	yellow	violet	red
3682	2682	6800	3775	–4,3	blue	grey	red
3103	2103	10 000	3875	–4,4	brown	black	orange
3153	2153	15 000	3800	–4,3	brown	green	orange
3223	2223	22 000	3850	–4,3	red	red	orange
3333	2333	33 000	3800	–4,3	orange	orange	orange
3473	2473	47 000	3850	–4,3	yellow	violet	orange
3683	2683	68 000	3900	–4,4	blue	grey	orange
3104	2104	100 000	3800	–4,3	brown	black	yellow
3154	2154	150 000	3880	–4,4	brown	green	yellow
3224	2224	220 000	3920	–4,4	red	red	yellow
3334	2334	330 000	3980	–4,5	orange	orange	yellow
3474	2474	470 000	4030	–4,5	yellow	violet	yellow
3684	2684	680 000	4100	–4,6	blue	grey	yellow

* Thermistors with 5% tolerance have a gold dot IV; 10% tolerance is identified by a silver dot IV (Fig. 1).

Maximum dissipation at + 55 °C	100 mW
Dissipation factor	0,6 mW/K approx.
Thermal time constant	9,5 s approx.
Heat capacity	
of ceramic	0,5 . 10^{-3} J/K approx.
of complete component	5,7 . 10^{-3} J/K approx.
Operating temperature range	
at zero power	–25 to + 200 °C
at maximum power	–25 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

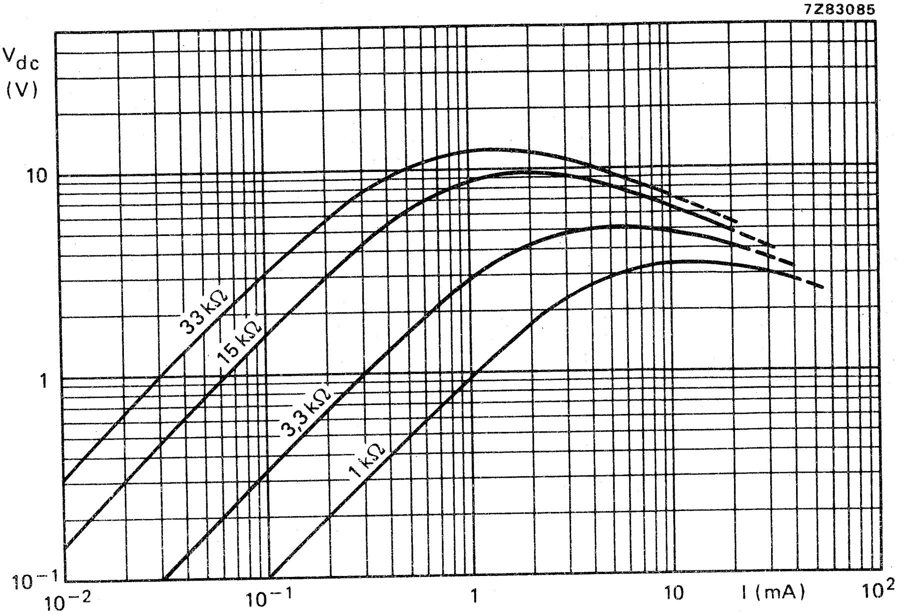


Fig. 2 Typical voltage/current characteristics.
T_{amb} = + 25 °C, still air.

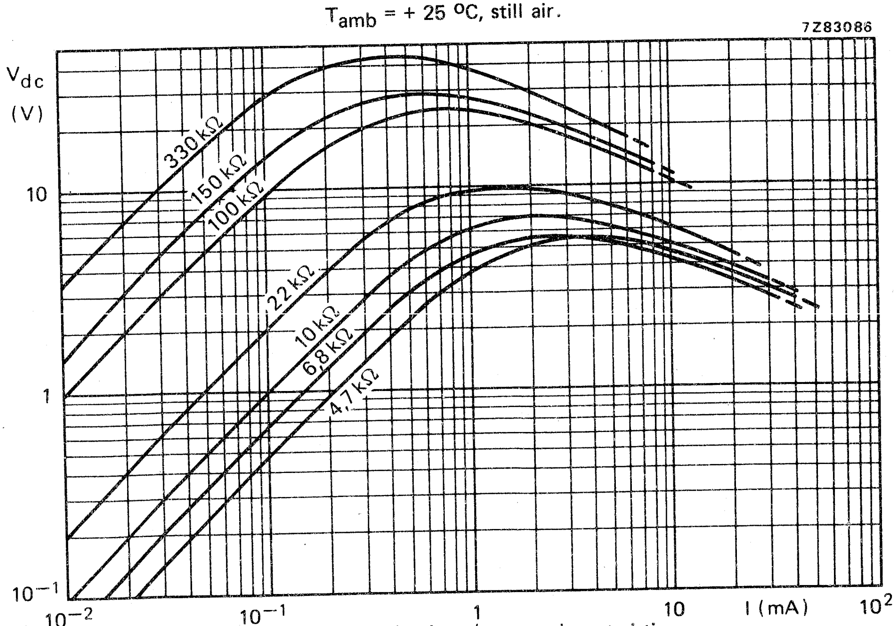


Fig. 3 Typical voltage/current characteristics.
T_{amb} = + 25 °C, still air.

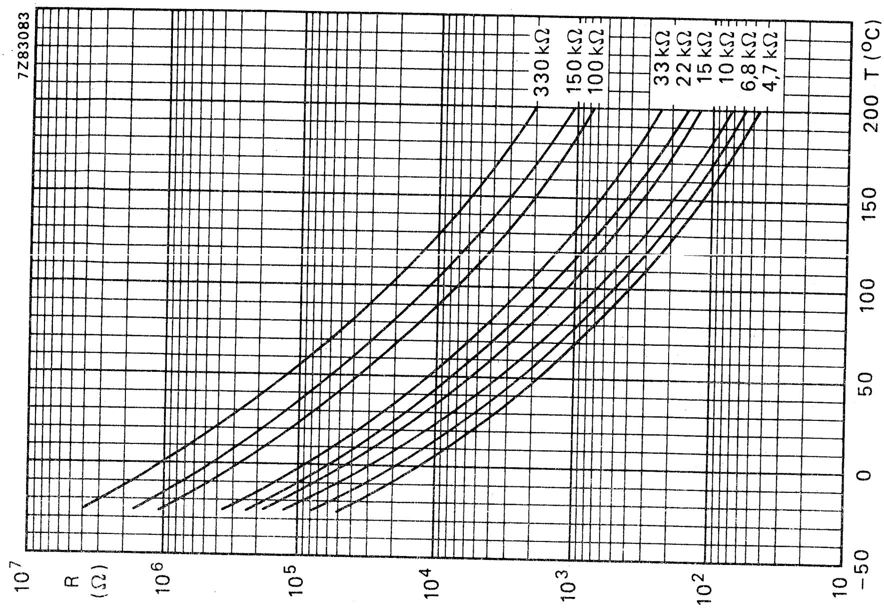


Fig. 5.

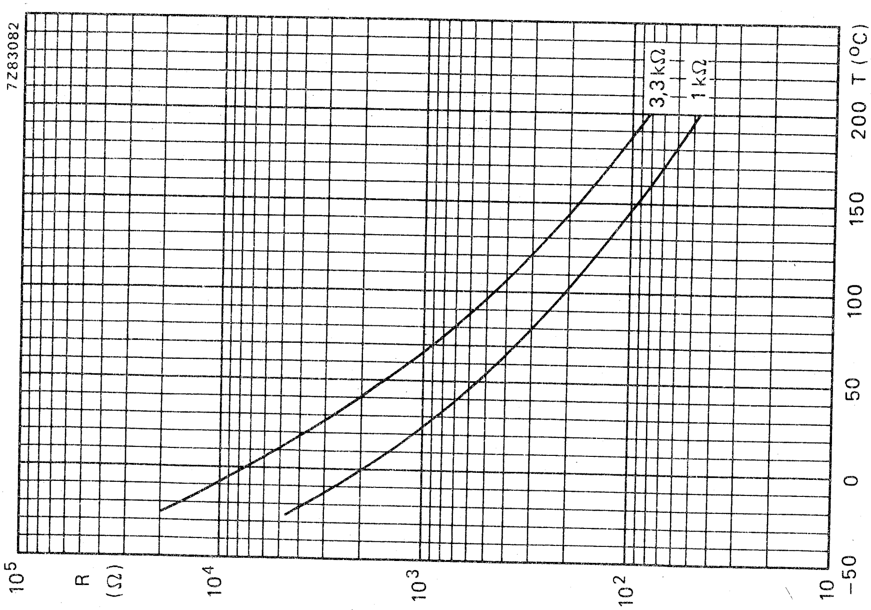


Fig. 4.

Typical resistance/temperature characteristics.

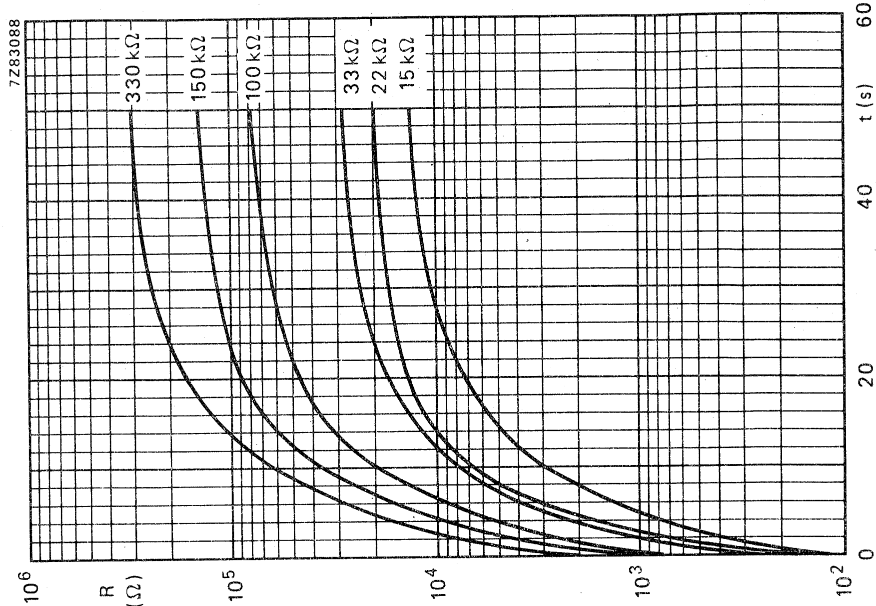


Fig. 7.

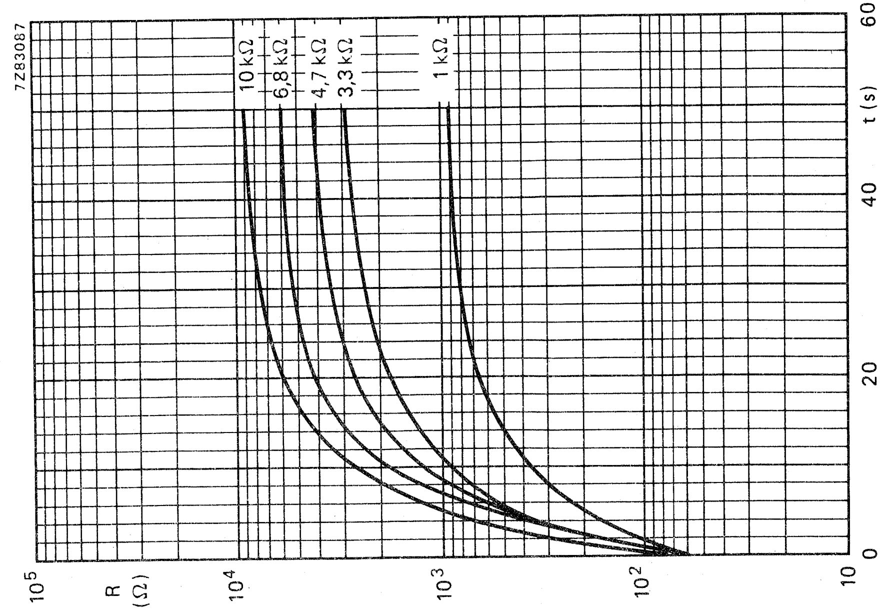


Fig. 6.

Typical resistance/time (cooling) characteristics.
T_{amb} = + 25 °C, still air; T_{start} = + 200 °C.

NTC THERMISTOR

indirectly heated

QUICK REFERENCE DATA

Resistance at +25 °C	15 kΩ
Resistance of heater	200 Ω
$B_{25/85}$ value	3860 K
Maximum dissipation of thermistor at W_h = 0 mW	15 mW
Operating temperature range	−25 to +85 °C

APPLICATION

Compensation in telecommunication amplifiers.

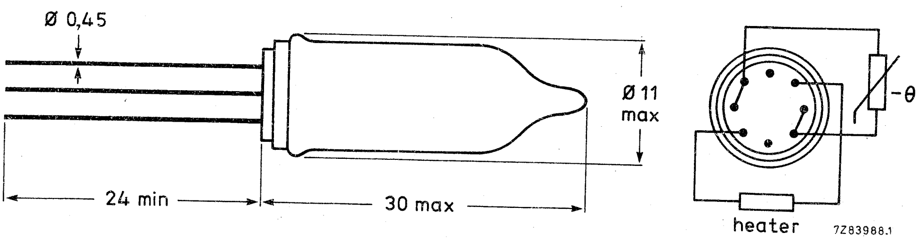
DESCRIPTION

Miniature thermistor with negative temperature coefficient, indirectly heated and vacuum mounted in a glass bulb.

MECHANICAL DATA

Unless otherwise specified, measured according to IEC80.

Outlines



Marking

R_{17} (± 2,5 %) and ratio $R_{9,5}/R_{17}$ (± 5%).

Mass

1,8 g approximately.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

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

Vibration

Severity 55 A

Impact

Shock	severity 50 A
Bump	severity 40 A/4000
Free fall	100 mm

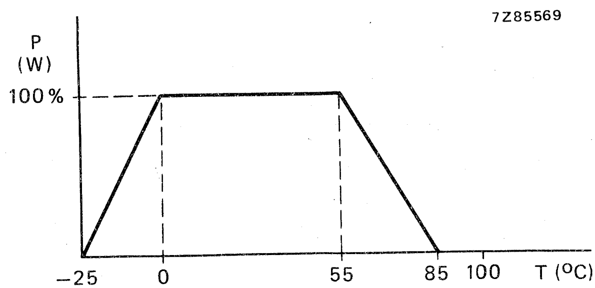
The terminal wires are tinned to max. 2 mm from the glass body, the wires of the heater are provided with a red sleeve.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC draft 40/043/74 of January 1977.

Type		2322 628 90016
$R_{25} \pm 30\%$		15 kΩ
Maximum resistance at 25 °C and I_h = 17 mA		55 Ω
Minimum ratio $R_{9,5}/R_{17}$		7,5
$R_h \pm 6\%$		200 Ω
$B_{25/85}$		3860 K
Temperature coefficient at +25 °C	~	−4,35 %/K
Maximum dissipation		
$W_h = 0$		15 mW
$W_{th} = 0$		65 mW
Maximum peak dissipation, $W_{th} = 0$		80 mW
Maximum capacitance between heater and thermistor at 1 MHz		6 pF
Operating temperature range		−25 to +85 °C

Derating curve:

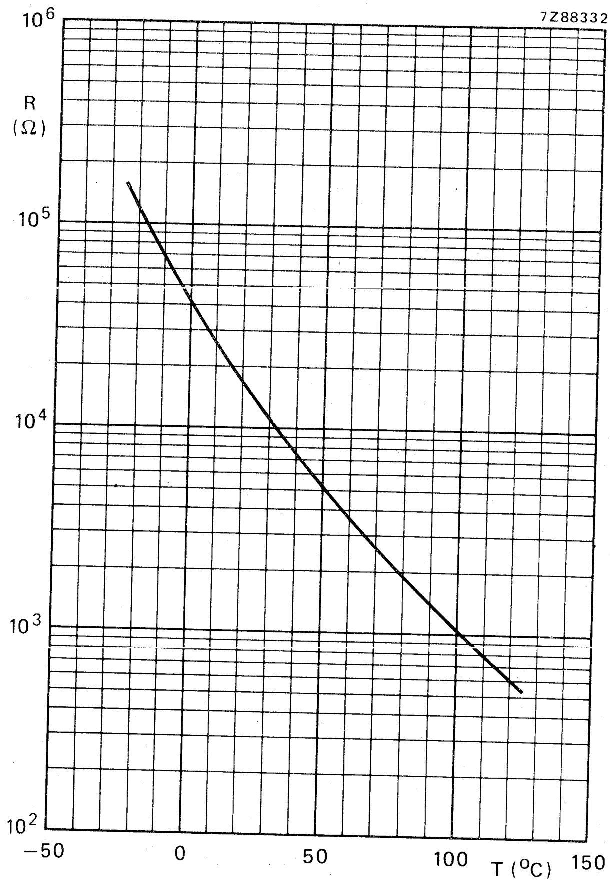


Dielectric withstanding voltage between terminals of thermistor and heater	min.	15 V
Insulation resistance at 10 V (d.c.) and I_h = 18 mA, between terminals of thermistor and heater	min.	5 MΩ

PACKAGING

200 per cardboard box

DEVELOPMENT SAMPLE DATA



Typical resistance/temperature characteristic.

NTC THERMISTORS

indirectly heated

QUICK REFERENCE DATA

Resistance at +25 °C	3,3 kΩ and 330 kΩ
Resistance of heater	100 Ω ± 10%
B 25/85 value	2750 K and 3980 K
Maximum dissipation of thermistor at W_h = 0 mW	65 mW
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C

APPLICATION

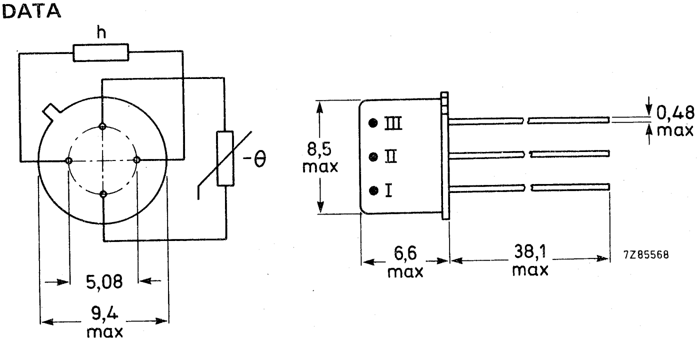
Intended for temperature control.

DESCRIPTION

Miniature thermistor with negative temperature coefficient, indirectly heated and mounted in an air-filled metal TO-5 envelope.

MECHANICAL DATA

Outlines



Marking

Three colour dots, to be read from left to right (leads down).

Mass

1 g approximately.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	5 N
Bending	2,5 N

Soldering

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

Impact

Free fall	100 mm

Uninflammable

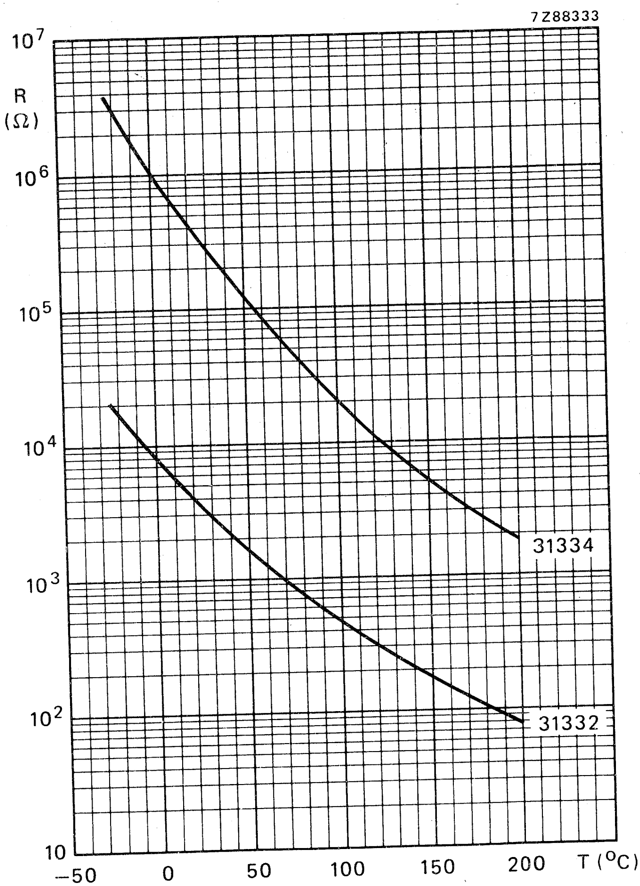
ELECTRICAL DATA

Unless otherwise specified, measured according to NF C 93-272 (May 1973).

Type		2322 628 31332	2322 628 31334	
Colour coding		orange/orange/red	orange/orange/yellow	
R_{25} ± 20%		3,3	330	kΩ
R_h ± 10%		100	100	Ω
R in % of R_{25} after t < 305, W_h = 30 mW		30	12,5	%
$B_{25/85}$ ± 5%		2750	3980	K
Temperature coefficient at +25 °C	≈	−3,1	−4,5	%/K
Maximum dissipation				
W_h = 0		65		mW
W_{th} = 0		80		mW
Operating temperature range				
zero power		−25 to +200		°C
maximum power		0 to +55		°C
Dielectric withstanding voltage (r.m.s.) between terminals of thermistor and heater min.		200		V
Insulation resistance at 50 V (d.c.) between terminals of thermistor and heater min.		10		MΩ

PACKAGING

100 per cardboard box.



Typical resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4100 K
Operating temperature range	
at zero power	−25 to + 200 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose.

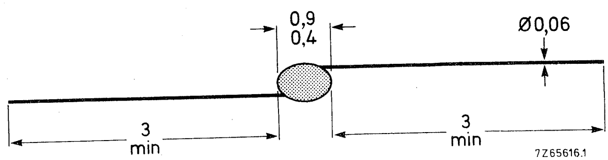
DESCRIPTION

Naked bead thermistor with negative temperature coefficient, with two solid platina-iridium leads in opposition or in same direction.

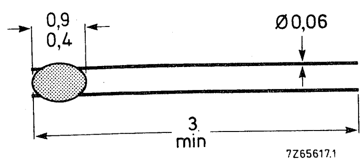
MECHANICAL DATA

Outlines

version 2322 634 0....



version 2322 634 1....



Marking
none

Mounting
In any position by spot welding of the leads to conducting wires or other supports.

Mass
1 mg approximately.

Inflammability
Uninflammable.

PACKAGING

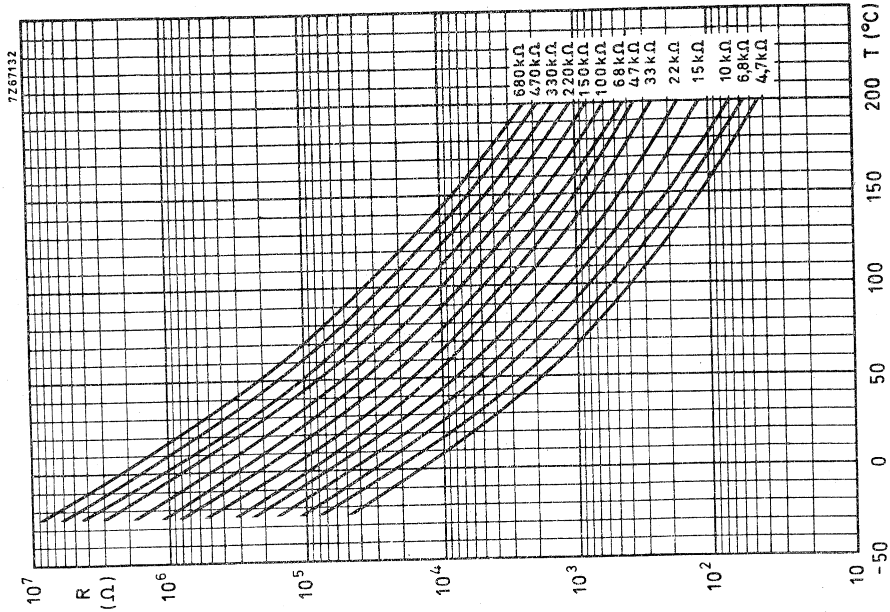
100 thermistors in a cardboard box.

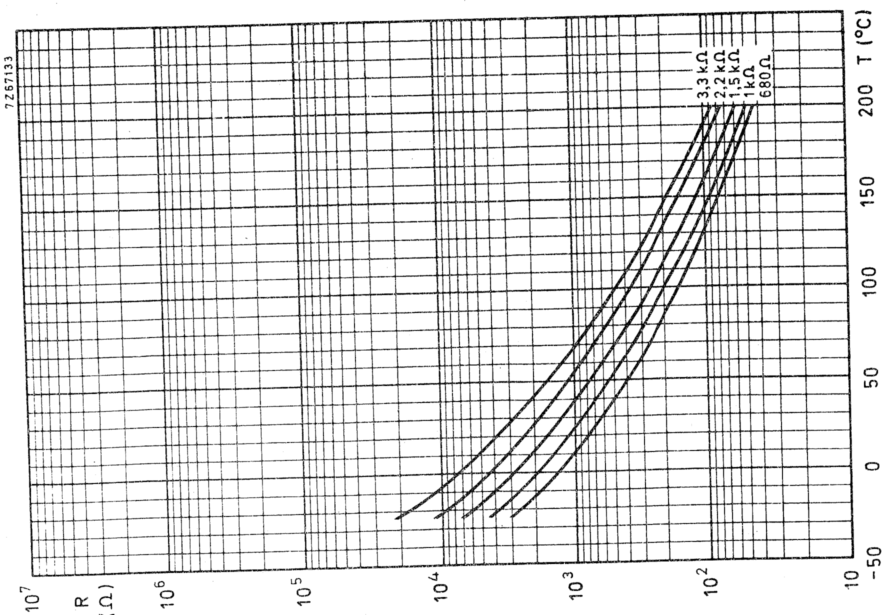
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

catalogue number 2322 634 0.... leads in opposition		catalogue number 2322 634 1.... leads in same direction		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C
tol. ± 5%	tol. ± 10%	tol. ± 5%	tol. ± 10%	Ω	K	%/K
3681	2681	3681	2681	680	2200	−2,5
3102	2102	3102	2102	1000	2375	−2,7
3152	2152	3152	2152	1500	2500	−2,1
3222	2222	3222	2222	2200	2600	−2,8
3332	2332	3332	2332	3300	2750	−3,1
3472	2472	3472	2472	4700	3725	−4,2
3682	2682	3682	2682	6800	3775	−4,3
3103	2103	3103	2103	10 000	3875	−4,3
3153	2153	3153	2153	15 000	3800	−4,3
3223	2223	3223	2223	22 000	3850	−4,3
3333	2333	3333	2333	33 000	3800	−4,3
3473	2473	3473	2473	47 000	3850	−4,3
3683	2683	3683	2683	68 000	3900	−4,4
3104	2104	3104	2104	100 000	3800	−4,3
3154	2154	3154	2154	150 000	3880	−4,4
3224	2224	3224	2224	220 000	3920	−4,4
3334	2334	3334	2334	330 000	3980	−4,5
3474	2474	3474	2474	470 000	4030	−4,5
3684	2684	3684	2684	680 000	4100	−4,6

Heat capacity	$0,5 \cdot 10^{-3}$ J/K; approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C





Typical resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	680 Ω to 680 kΩ (E6 series)
$B_{25/85}$-value	2200 to 4100 K
Maximum dissipation	60 mW
Dissipation factor	0,4 mW/K
Thermal time constant	9 s
Operating temperature range	
at zero power	−25 to + 200 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose.

DESCRIPTION

Bead thermistor with negative temperature coefficient, in a glass envelope with two tinned copper wires.

MECHANICAL DATA

Outlines

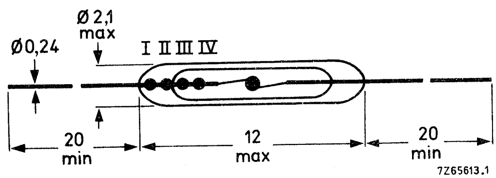


Fig. 1.

Marking
Colour dots on the glass envelope, see Fig. 1 and Table 1.

Mass
0,1 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.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

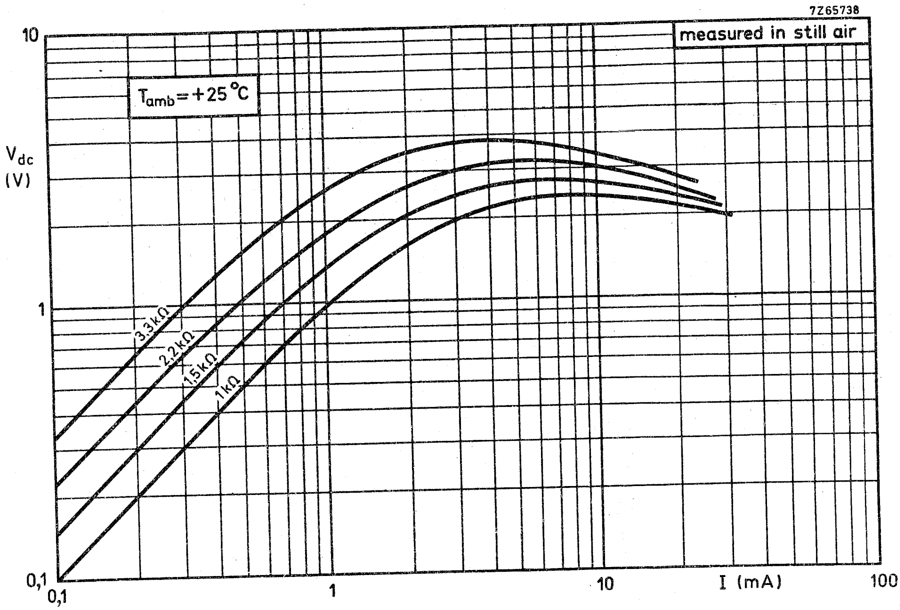
Unless otherwise specified, measured according to IEC publication 539.

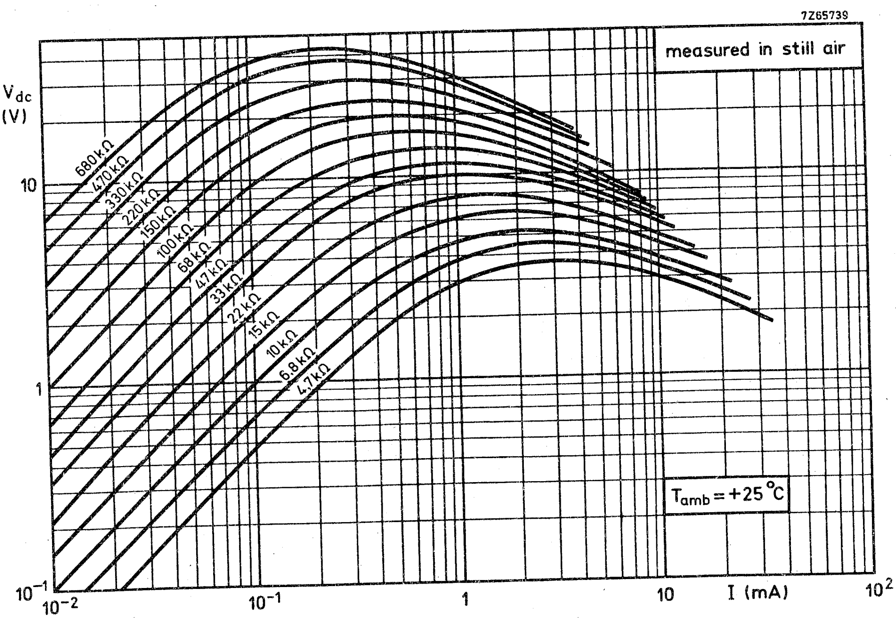
Table 1 Catalogue number 2322 634 2.....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code *		
tol. ± 5 %	tol. ± 10%	Ω	K	%/K	I	II	III
3681	2681	680	2200	–2,5	blue	grey	brown
3102	2102	1000	2375	–2,7	brown	black	red
3152	2152	1500	2500	–2,8	brown	green	red
3222	2222	2200	2600	–2,9	red	red	red
3332	2332	3300	2750	–3,1	orange	orange	red
3472	2472	4700	3725	–4,2	yellow	violet	red
3682	2682	6800	3775	–4,3	blue	grey	red
3103	2103	10 000	3875	–4,3	brown	black	orange
3153	2153	15 000	3800	–4,3	brown	green	orange
3223	2223	22 000	3850	–4,3	red	red	orange
3333	2333	33 000	3800	–4,3	orange	orange	orange
3473	2473	47 000	3850	–4,3	yellow	violet	orange
3683	2683	68 000	3900	–4,4	blue	grey	orange
3104	2104	100 000	3800	–4,3	brown	black	yellow
3154	2154	150 000	3880	–4,4	brown	green	yellow
3224	2224	220 000	3920	–4,4	red	red	yellow
3334	2334	330 000	3980	–4,5	orange	orange	yellow
3474	2474	470 000	4030	–4,5	yellow	violet	yellow
3684	2684	680 000	4100	–4,6	blue	grey	yellow

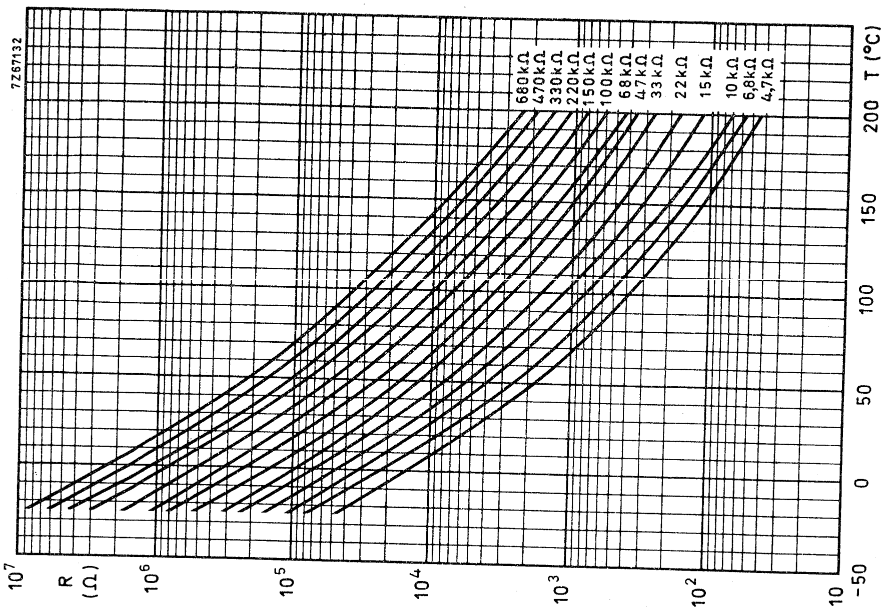
* Thermistors with 5% tolerance have a gold dot IV; 10% tolerance is identified by a silver dot IV (Fig. 1).

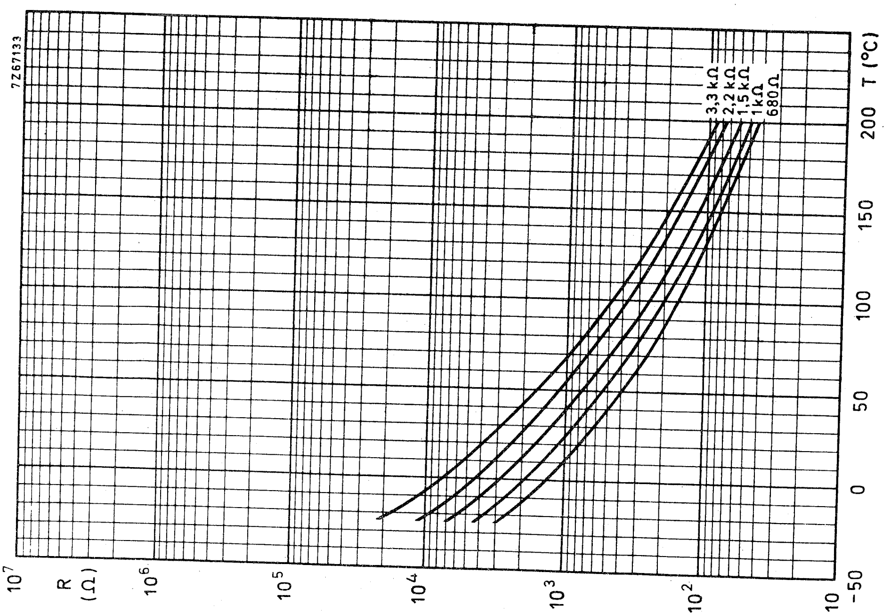
Maximum dissipation at +55 °C	60 mW
Dissipation factor	0,4 mW/K approx.
Thermal time constant	9 s approx.
Heat capacity	
of ceramic	$0,5 \cdot 10^{-3}$ J/K approx.
of complete component	$3.1 \cdot 10^{-3}$ J/K approx.
Operating temperature range	
at zero power	–25 to +200 °C
at maximum power	0 to +55 °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





Typical voltage/current characteristics.





Typical resistance/temperature characteristics.

NTC THERMISTORS

rod

QUICK REFERENCE DATA

Resistance values at + 25 °C	4,7 kΩ to 470 kΩ
$B_{25/85}$-value	3300 to 4300 K
Maximum dissipation	0,6 W
Dissipation factor	5 mW/°C
Thermal time constant	30 s
Operating temperature range	
at zero power	−25 to + 155 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose.

DESCRIPTION

Rod thermistors with a negative temperature coefficient with two tangential tinned copper wires. They are neither lacquered nor insulated.

MECHANICAL DATA

Outlines

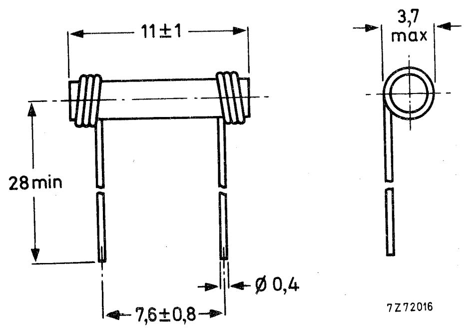


Fig. 1.

Marking

The thermistors have one or two colour dots in the middle of the rod, see table. Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Mass 0,32 g approximately.

Mounting In any position by soldering.

Robustness of terminations

Tensile strength — 5 N

Bending — 2,5 N

Soldering

Solderability — max. 240 °C, max. 4 s

Resistance to heat — max. 265 °C, max. 11 s.

PACKAGING

250 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified measured according to IEC publication 539.

catalogue number		R_{25}	$R_{25/85}$ ± 5%	temperature coefficient *	colour ** code
tol. ± 20%	tol. ± 10% **	kΩ	K	%/K	
2322 635 01472	2322 635 02472	4,7	3300	–3,70	orange
2332 635 01153	2322 635 02153	15	3600	–4,05	green
2322 635 01473	2322 635 02473	47	3925	–4,25	blue
2322 635 01154	2322 635 02154	150	4075	–4,65	white
2322 635 01334	2322 635 02334	330	4250	4,85	yellow/blue
2322 635 01474	2322 635 02474	470	4300	–4,75	yellow/orange

Maximum dissipation — 0,6 W

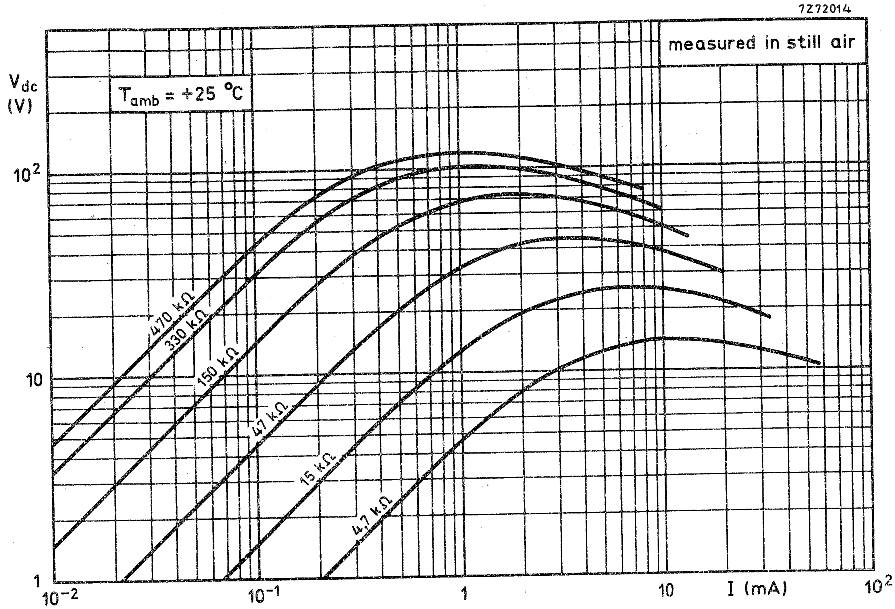
Dissipation factor — 5 mW/K *

Thermal time constant — 30 s *

Heat capacity
- of ceramic — 0,135 J/K *
- of complete component — 0,150 J/K *

Operating temperature range
- at zero power — –25 to + 155 °C
- at maximum power — 0 to + 55 °C

* Approximate values, measured in the test set, according to NFC93-271.
** See "Marking".



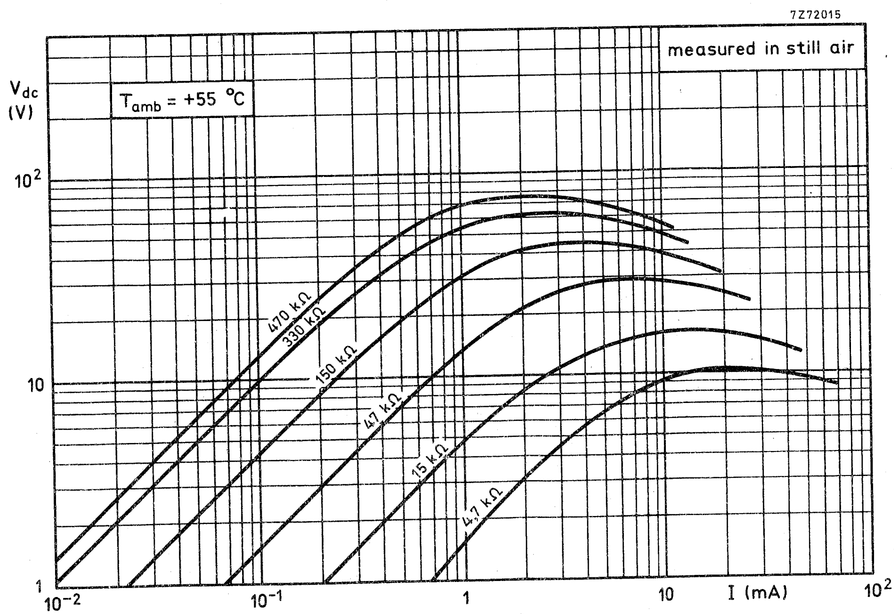


Fig. 2a and b Typical voltage/current characteristics.

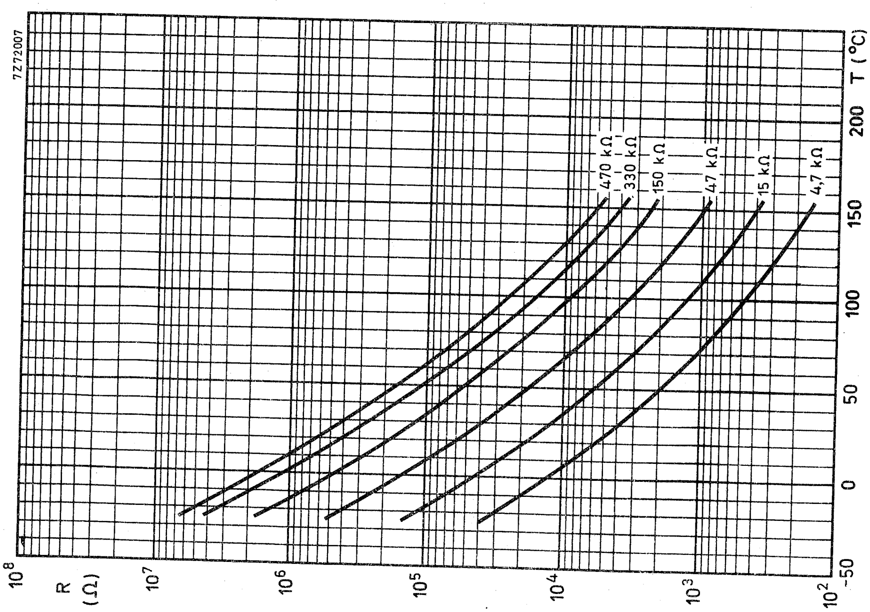


Fig. 3 Typical resistance/temperature characteristics.

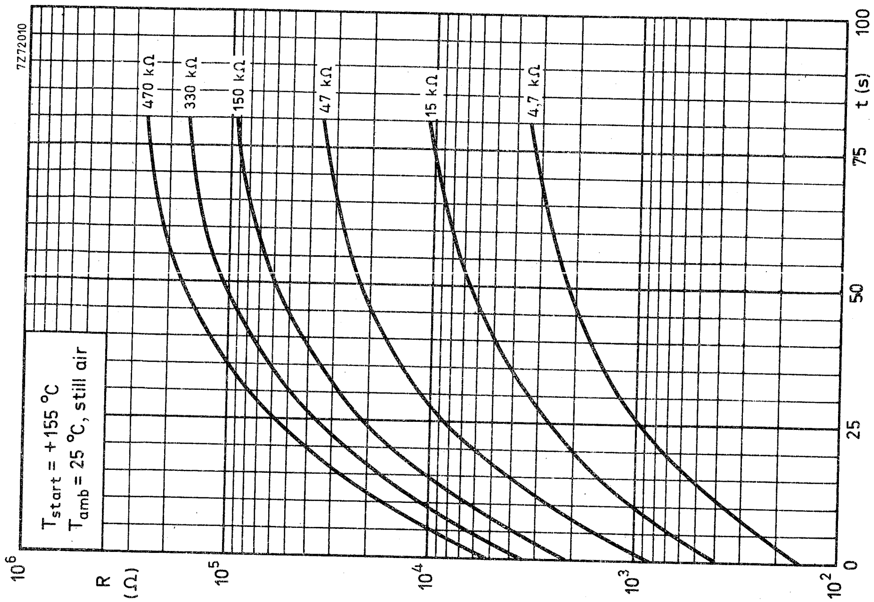


Fig. 4 Typical resistance/time (cooling) characteristics.

NTC THERMISTORS

rod

QUICK REFERENCE DATA

Resistance values at +25 °C	4,7 kΩ to 150 kΩ
$B_{25/85}$-value	3250 to 4150 K
Maximum dissipation	1,5 W
Dissipation factor	10 mW/K
Thermal time constant	55 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

General purpose.

DESCRIPTION

Rod thermistors with a negative temperature coefficient, with two tangential tinned copper wires. They are neither lacquered nor insulated.

MECHANICAL DATA

Outlines

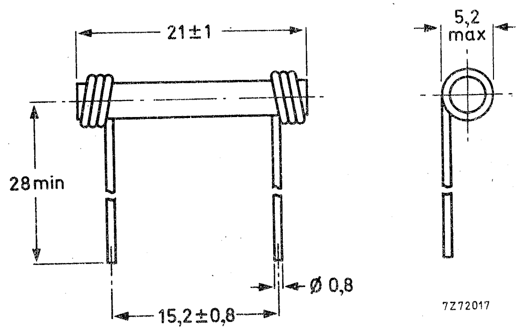


Fig. 1.

Marking

The thermistors have a colour dot in the middle of the rod, see table. Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Mass 1,25 g approximately.

Mounting In any position by soldering.

Robustness of terminations

Tensile strength 20 N

Bending 10 N

Soldering

Solderability max. 240 °C, max. 4 s

Resistance to heat max. 265 °C, max. 11 s

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

catalogue number		R_{25}	$B_{25/85}$ ± 5%	temperature coefficient *	colour ** code
tol. ± 20%	tol. ± 10% **	kΩ	K	%/K	
2322 636 01472	2322 636 02472	4,7	3250	−3,55	orange
2322 636 01153	2322 636 02153	15	3550	−4,0	green
2322 636 01473	2322 636 02473	47	4000	−4,5	blue
2322 636 01154	2322 636 02154	150	4150	−4,65	white

Maximum dissipation 1,5 W

Dissipation factor 10 mW/K *

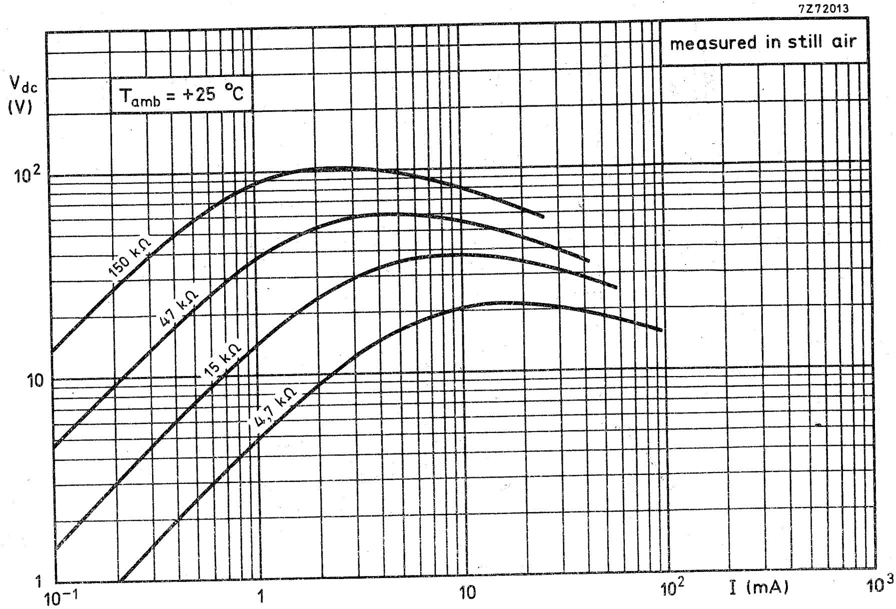
Thermal time constant 55 s *

Heat capacity
- of ceramic 0,44 J/K *
- of complete component 0,55 J/K *

Operating temperature range
- at zero power −25 to + 155 °C
- at maximum power 0 to + 55 °C

* Approximate values, measured in the test set according to NF C93-271.
** See "marking".

7Z72013



7Z72012

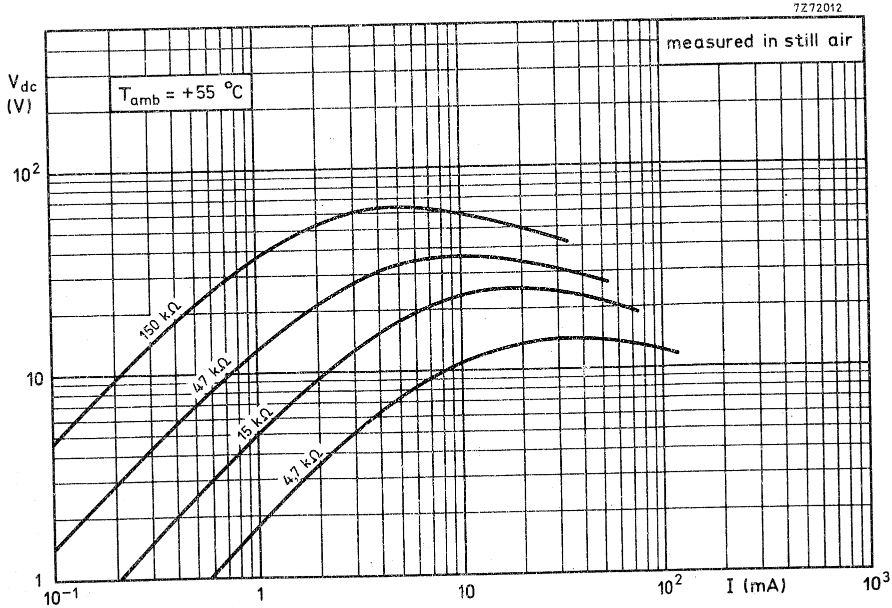


Fig. 2a and b Typical voltage/current characteristics.

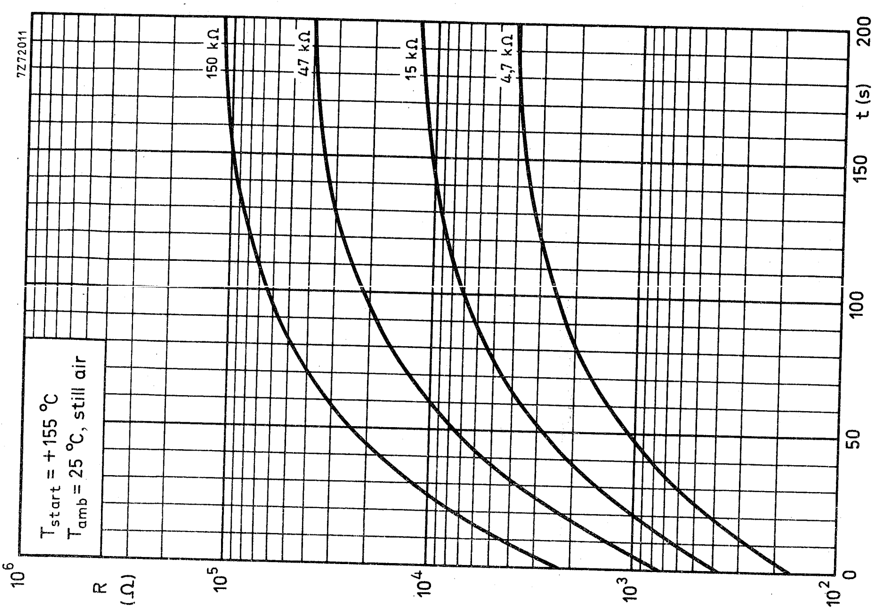


Fig. 4 Typical resistance/time (cooling) characteristics.

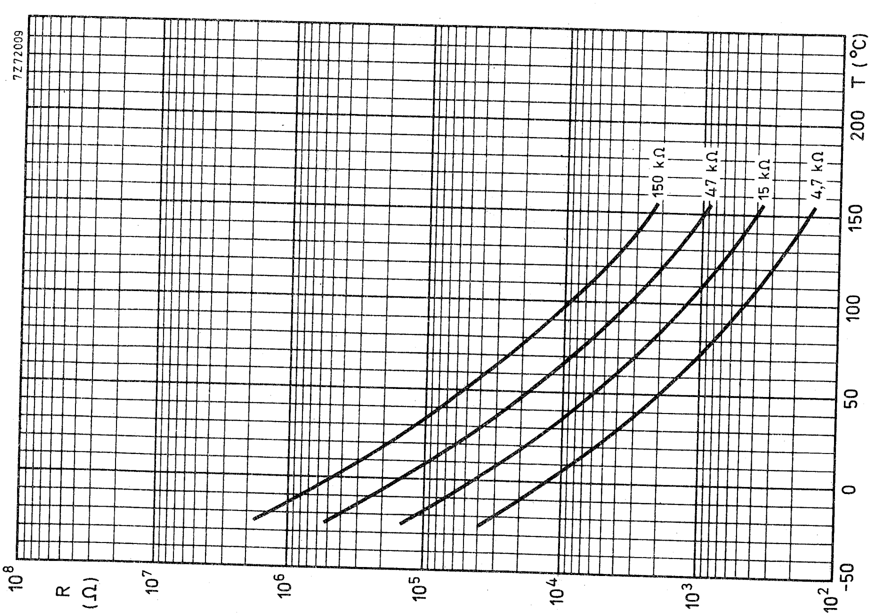


Fig. 3 Typical resistance/temperature characteristics.

NTC THERMISTORS

rod

QUICK REFERENCE DATA

Resistance values at + 25 °C	4,7 kΩ to 150 kΩ
$B_{25/85}$-value	3200 to 4200 K
Maximum dissipation	2,3 W
Dissipation factor	17 mW/K
Thermal time constant	105 s
Operating temperature range	
at zero power	−25 to + 155 °C
at maximum power	0 to + 55 °C

APPLICATION

General purpose.

DESCRIPTION

Rod thermistors with a negative temperature coefficient, with two tangential tinned copper wires. They are neither lacquered nor insulated.

MECHANICAL DATA

Outlines

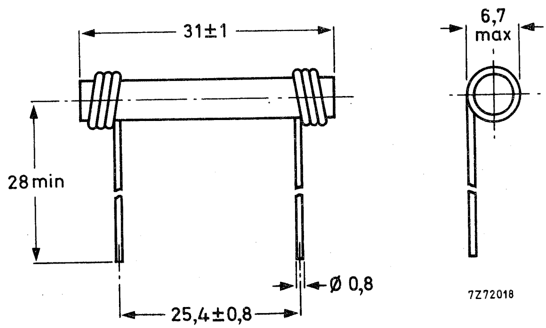


Fig. 1.

Marking

The thermistors have a colour dot in the middle of the rod, see table. Types with a tolerance of 10% on R_{25} also have a red dot at one end.

Mass 2,65 g approximately

Mounting In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

PACKAGING

50 thermistors in a cardboard box

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

catalogue number		R_{25}	$R_{25/85}$ ± 5%	temperature coefficient *	colour ** code
tol. ± 20%	tol. ± 10% **	%/K	K	%/K	
2322 637 01472	2322 637 02472	4,7	3200	–3,6	orange
2322 637 01153	2322 637 02153	15	3550	–4,0	green
2322 637 01473	2322 637 02473	47	4000	–4,2	blue
2322 637 01154	2322 637 02154	150	4200	–4,7	white

Maximum dissipation	2,3 W
Dissipation factor	17 mW/K *
Thermal time constant	105 s *
Heat capacity	1,785 J/K *
Operating temperature range	
at zero power	–25 to + 155 °C
at maximum power	0 to + 55 °C

* Approximate values, measured in the test set according to NF C 93-271.
** See "marking".

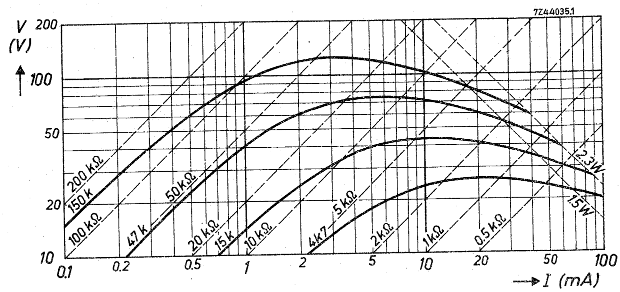


Fig. 2 Typical voltage/current characteristics.

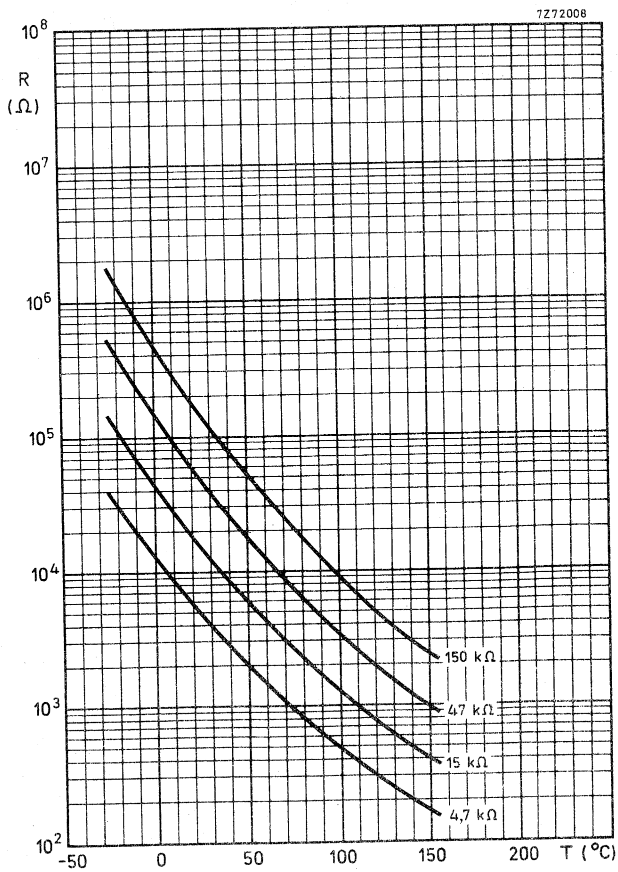


Fig. 3 Typical resistance/temperature characteristics.

NTC THERMISTORS

QUICK REFERENCE DATA

Resistance value at +25 °C	2,7 to 330 kΩ
$B_{25/85}$ value	3660 to 4150 K
Maximum dissipation	0,25 W
Dissipation factor	7,5 mW/K
Thermal time constant	19 s
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

General purpose.

DESCRIPTION

The thermistor has a negative temperature coefficient. It consists of a disc with two tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Outlines

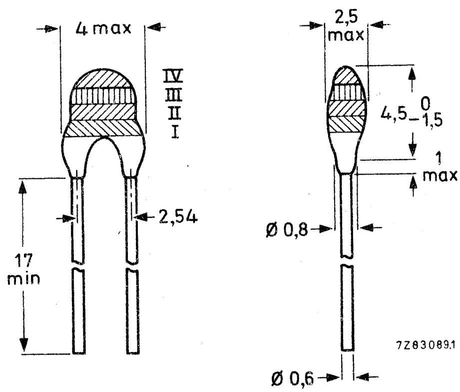


Fig. 1.

Marking

The thermistors are marked with colour bands in accordance with Fig. 1 and Table 1.

Mass

0,14 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

Impact

Free fall	1 m

Uninflammable

Resistant to cleaning solvents

PACKAGING

500 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Maximum dissipation at T_{amb} = +55 °C *	0,25 W
Dissipation factor*	7,5 mW/K approx.
Thermal time constant (τ_c) *	19 s approx.
Heat capacity*	0,135 J/K approx.
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to + 55 °C

* Measured in the measuring set described in the French norm NF C93-271, and clamped at 10 mm from the body.

Table 1

catalogue number 2322 640 1....		R_{25}	$B_{25/85}$ ± 5%	$B_{-25/25}$ ± 5%	temperature coefficient at +25 °C	colour code *		
R_{25} ± 5%	R_{25} ± 10%	Ω	K	K	%/K	I	II	III
3272	2272	2 700	4000	3800	−4,50	red	violet	red
3472	2472	4 700	3660	3440	−4,12	yellow	violet	red
3123	2123	12 000	3700	3540	−4,17	brown	red	orange
3223	2223	22 000	3700	3420	−4,17	red	red	orange
3473	2473	47 000	3850	3570	−4,33	yellow	violet	orange
3683	2683	68 000	3880	3590	−4,37	blue	grey	orange
3154	2154	150 000	4050	3740	−4,56	brown	green	yellow
3334	2334	330 000	4150	3830	−4,67	orange	orange	yellow

* Thermistors with a 5% tolerance have a gold band IV; 10% tolerance is identified by a silver band IV (Fig. 1). If band IV is not used see 2322 640 19...

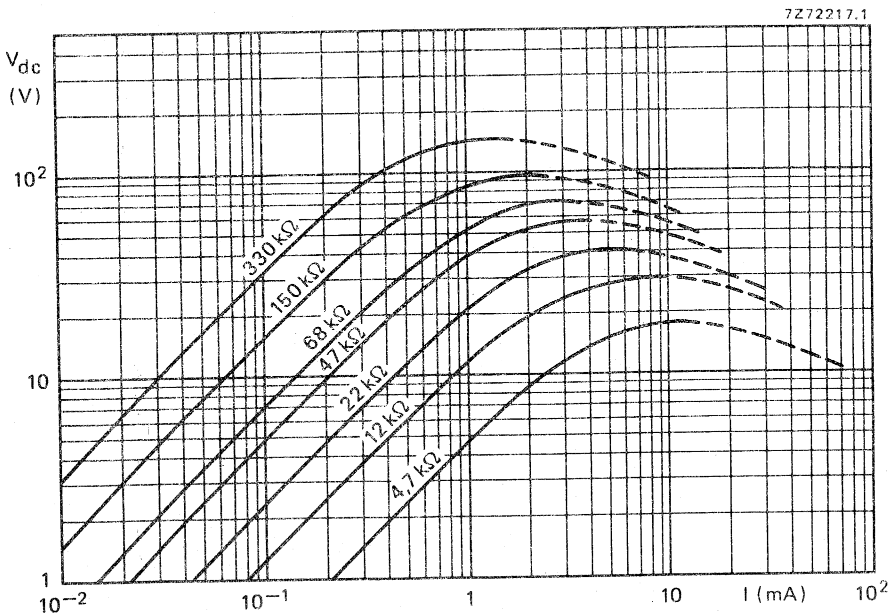


Fig. 2 Typical voltage/current characteristics. T_{amb} = +25 °C, still air.

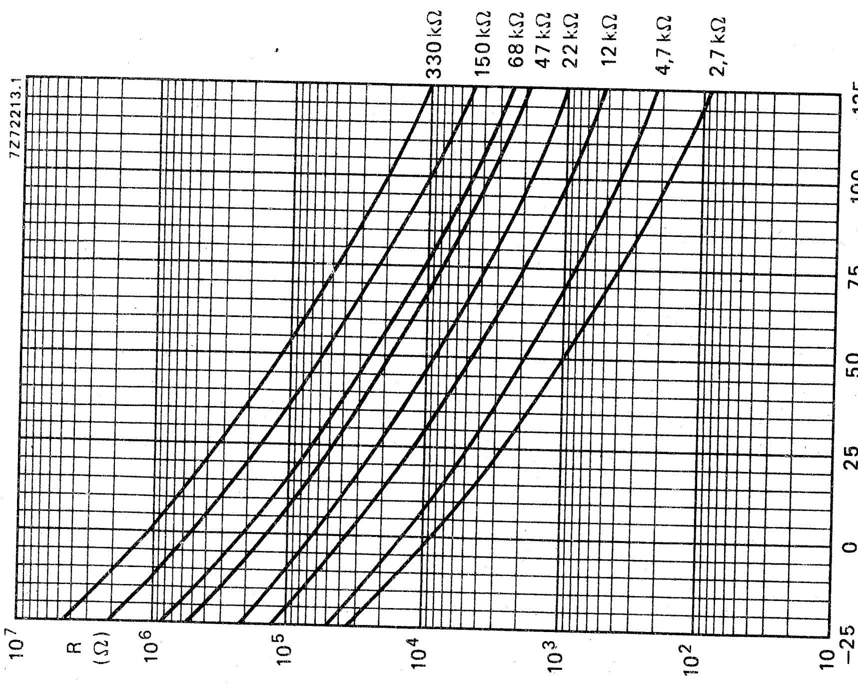


Fig. 3 Typical resistance/temperature characteristic.

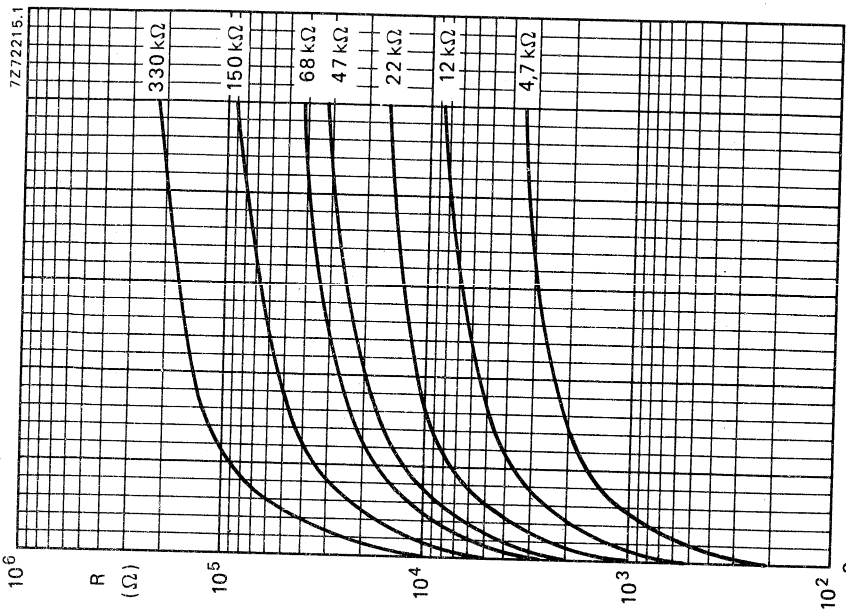


Fig. 4 Typical resistance/time (cooling) characteristic. T_{amb} = + 25 °C, still air; T_{start} = + 125 °C.

NTC THERMISTORS

two-point sensors

APPLICATION

For temperature measurement between 0 and 30 °C.

DESCRIPTION

The thermistor has a negative temperature coefficient. It consists of a disc with two tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Outlines

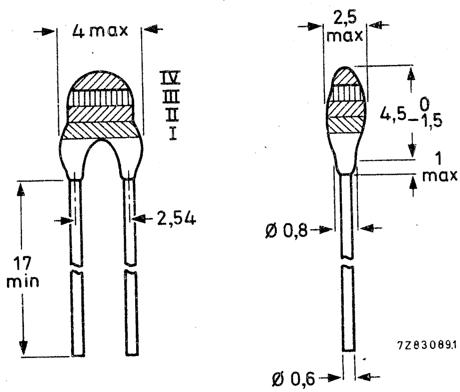


Fig. 1.

Marking

The thermistors are marked with colour bands, see table for colour code.

Resistant to cleaning solvents

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Maximum dissipation at T_{amb} = + 55 °C*	0,25 W
Dissipation factor*	7,5 mW/K approx.
Thermal time constant (τ_c)*	19 s approx.
Heat capacity*	0,135 J/K approx.
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

* Measured in the measuring set described in the French standard NF C93-271, and clamped at 10 mm from the body.

catalogue number	nominal resistance value Ω		colour code*		
2322 640 19 . . .	5 ± 1 °C	25 ± 1 °C	I	II	III
472	10 900	4 700	yellow	violet	red
103	23 000	10 000	brown	black	orange
223	52 000	22 000	red	red	orange
473	114 000	47 000	yellow	violet	orange
104	250 000	100 000	brown	black	yellow
224	567 000	220 000	red	red	yellow

* Band IV is not used.
The nominal resistance value should be reached between 4 and 6 °C and also between 24 and 26 °C.

NTC THERMISTORS

moulded

QUICK REFERENCE DATA

	2322 640 90004	2322 640 98004	
Resistance value at			
+25 °C	12 ± 7%	12 ± 7%	kΩ
+100 °C	950 ± 5%	950 ± 5%	Ω
$B_{25/85}$-value	3750	3750	K
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/K
when mounted on a heat-sink	19	27	mW/K
Thermal time constant	19	33	s
when mounted on a heat-sink	10	5	s
Operating temperature range			
at zero power	−10 to +125	−10 to +125	°C
at maximum power	0 to +55	0 to +55	°C

APPLICATION

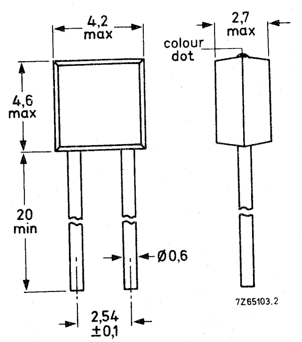
For temperature control.

DESCRIPTION

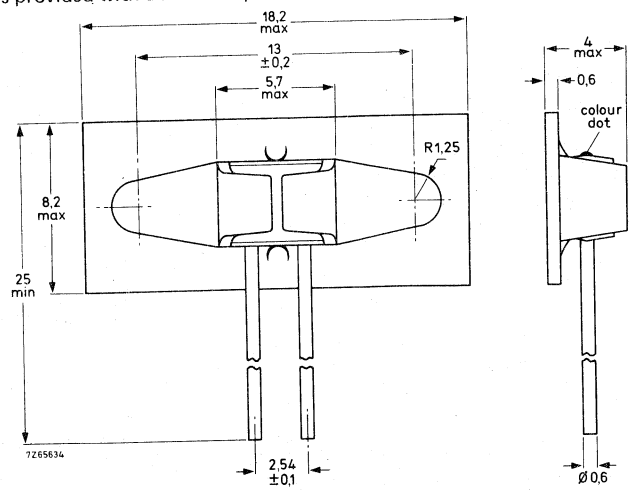
Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires. The body colour is dark grey.
The thermistor 2322 640 98004 is provided with a metal strip for mounting.

MECHANICAL DATA

Outlines



type 2322 640 90004



type 2322 640 98004
with metal strip for mounting

Marking

The thermistors have a grey dot.

Mass

Type 2322 640 90004	0,3 g approx.
Type 2322 640 98004	0,5 g approx.

Mounting

Type 2322 640 90004	in any position by soldering
Type 2322 640 98004	by means of the mounting strip

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

Impact

Free fall	1 m

Inflammability

Uninflammable – CCTU-01-01A specification, test 22.

PACKAGING

Type 2322 640 90004: 500 thermistors in a cardboard box.
Type 2322 640 98004: 400 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

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

	2322 640 90004	2322 640 98004	
Resistance at			
+25 °C	12 ± 7%	12 ± 7%	kΩ
+100 °C	950 ± 5%	950 ± 5%	Ω
$B_{25/85}$-value	3750	3750	K
Temperature coefficient	–4,2	–4,2	%/K
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/K
when mounted on a heatsink *	19	27	mW/K
Thermal time constant (τ_c)	19	33	s
when mounted on a heatsink *	10	5	s
Heat capacity of ceramic	0,028	0,028	J/K
of complete component	0,13	0,3	J/K
Response time (τ_r)**	3	3	s
Operating temperature range			
at zero power	–10 to +125	–10 to +125	°C
at maximum power	0 to +55	0 to +55	°C
Dielectric withstanding voltage (r.m.s.) between terminals and coating/strip	min. 350	min. 350	V
Insulation resistance between terminals and coating/strip at 100 V (d.c.)	min. 100	min. 100	MΩ

* Measurements made in still air with the thermistor mounted on a heatsink of 100 cm^2, thickness 1,5 mm, and connected between phosphor-bronze wires (ϕ1,3 mm).

** The thermistor being transferred from ambient air of +25 °C to a silicone oil (MS200/50) bath of +85 °C.

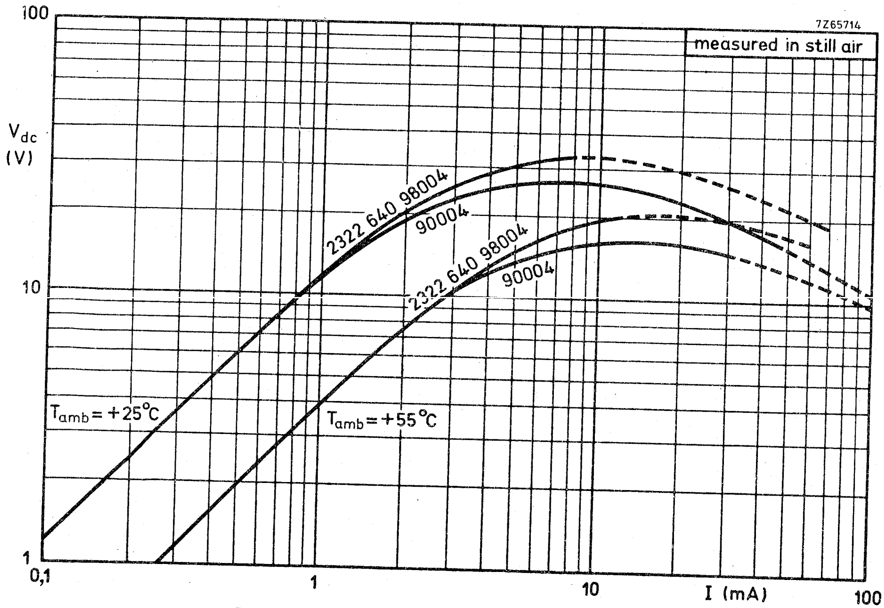


Fig. 2 Typical voltage/current characteristics.

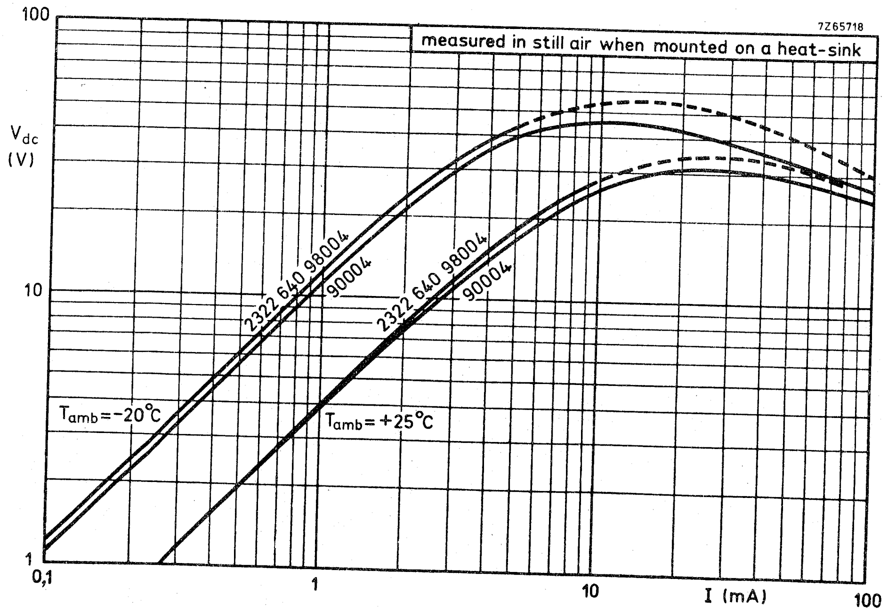


Fig. 3 Typical voltage/current characteristics.

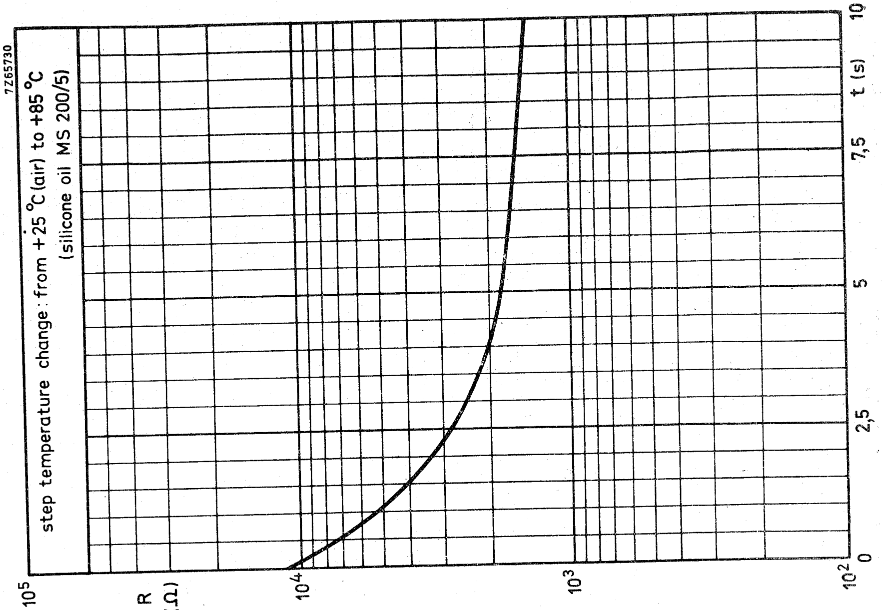


Fig. 5 Typical resistance/response time characteristics.

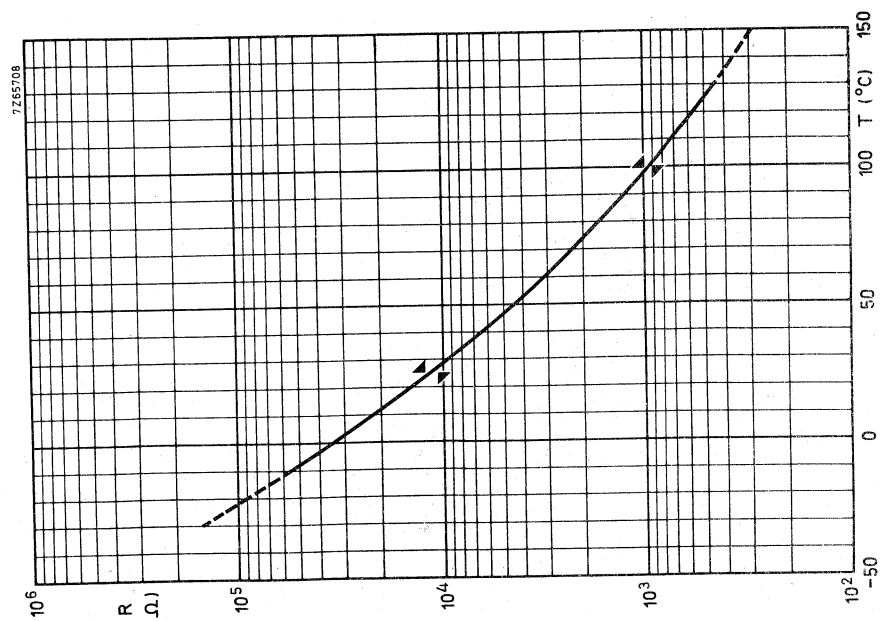


Fig. 4 Typical resistance/temperature characteristics.

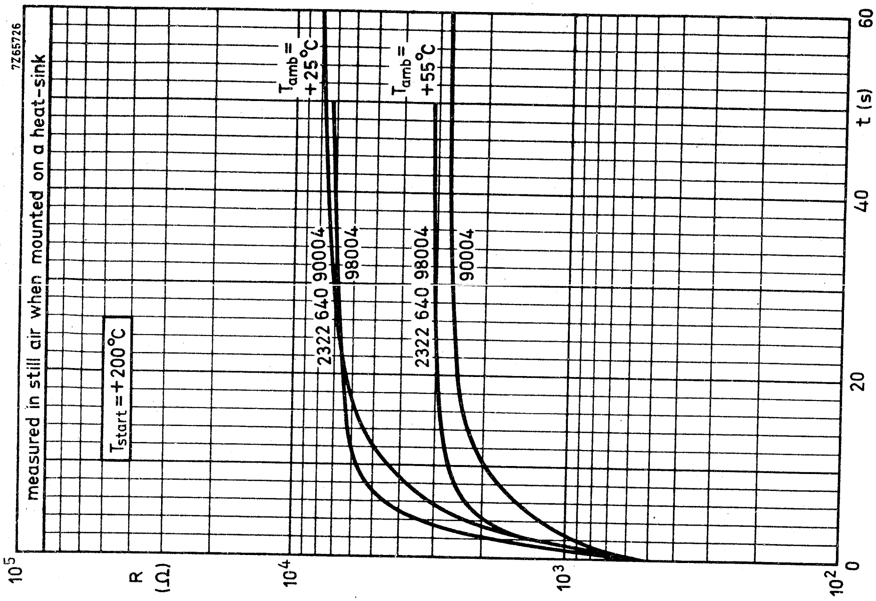


Fig. 7 Typical resistance/time (cooling) characteristics.

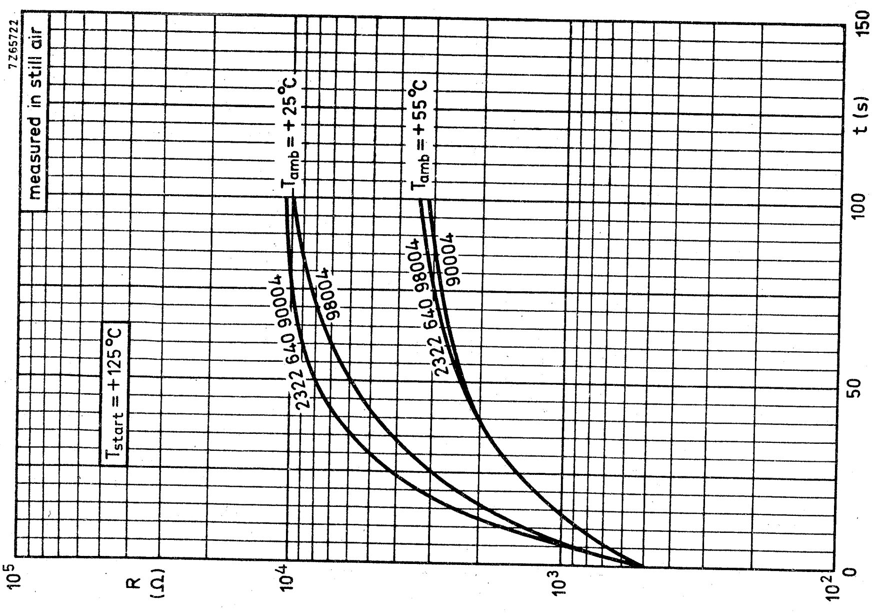


Fig. 6 Typical resistance/time (cooling) characteristics.

NTC THERMISTORS
moulded

QUICK REFERENCE DATA

	2322 640 90005	2322 640 98005	
Resistance at			
+ 100 °C	16,7 ± 7%	16,7 ± 7%	kΩ
+ 200 °C	1120 ± 7%	1120 ± 7%	Ω
$B_{25/85}$-value	4300	4300	K
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/K
when mounted on a heat-sink	17,5	20,5	mW/K
Thermal time constant	19	33	s
when mounted on a heat-sink	12	8,5	s
Operating temperature range			
at zero power	−25 to + 200	−25 to + 200	°C
at maximum power	0 to + 55	0 to + 55	°C

APPLICATION

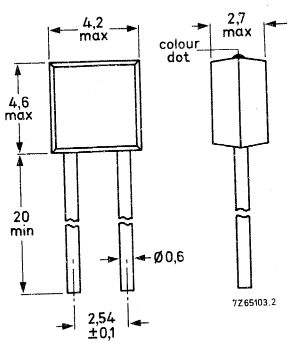
For high temperature control.

DESCRIPTION

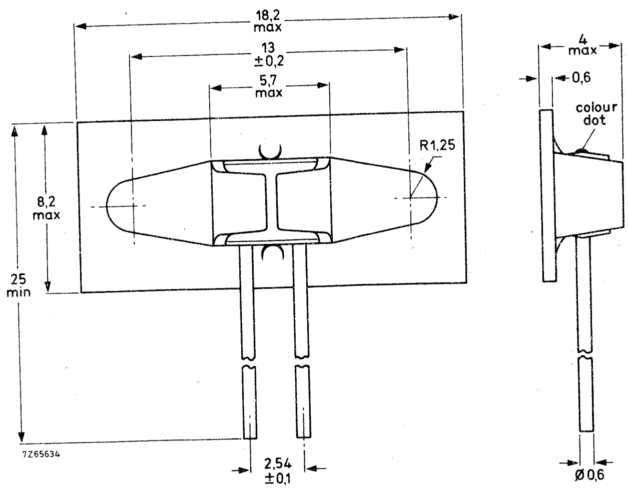
Moulded disc thermistor with negative temperature control and with two solid tinned copper wires.
The body colour is dark grey.
The thermistor 2322 640 98005 is provided with a metal strip for mounting.

MECHANICAL DATA

Outlines



type 2322 640 90005



type 2322 640 98005
with metal strip for mounting

Marking

The thermistors have a black dot.

Mass

Type 2322 640 90005	0,3 g approx.
Type 2322 640 98005	0,5 g approx.

Mounting

Type 2322 640 90005	in any position by soldering
Type 2322 640 98005	by means of the mounting strip

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

Impact

Free fall	1 m

Inflammability

Uninflammable – CCTU-01-01A specification, test 22.

PACKAGING

Type 2322 640 90005: 500 thermistors in a cardboard box.
Type 2322 640 98005: 400 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measuring according to IEC publication 539.

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

	2322 640 90005	2322 640 98005	
Resistance at			
+ 100 °C	16,7 ± 7%	16,7 ± 7%	kΩ
+ 200 °C	1120 ± 7%	1120 ± 7%	Ω
+ 25 °C	310	310	kΩ
$B_{25/85}$-value	4300	4300	K
Temperature coefficient	–4,85	–4,85	%/K
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/K
when mounted on a heatsink *	17,5	20,5	mW/K
Thermal time constant (τ_c)	19	33	s
when mounted on a heatsink *	12	8,5	s
Heat capacity of ceramic	0,028	0,028	J/K
of complete component	0,13	0,31	J/K
Response time (τ_r) **	3	3	s
Operating temperature range			
at zero power	–25 to + 200	–25 to + 200	°C
at maximum power	0 to + 55	0 to + 55	°C
Dielectric withstanding voltage (r.m.s.) between terminals and coating	min. 350	min. 350	V
Insulation resistance between terminals and coating at 100 V (d.c.)	min. 100	min. 100	MΩ

* Measurements made in still air with the thermistor mounted on a heatsink of 100 cm^2, thickness 1,5 mm, connected between phosphor-bronze wires (ϕ 1,3 mm).

** The thermistor being transferred from ambient air of + 25 °C to a silicone oil (MS200/50) bath of + 85 °C.

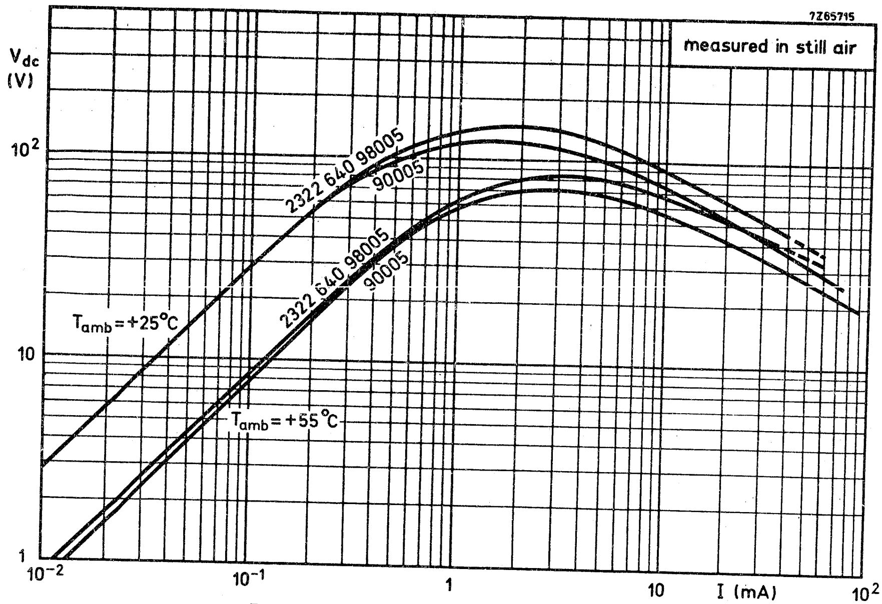


Fig. 2 Typical voltage/current characteristics.

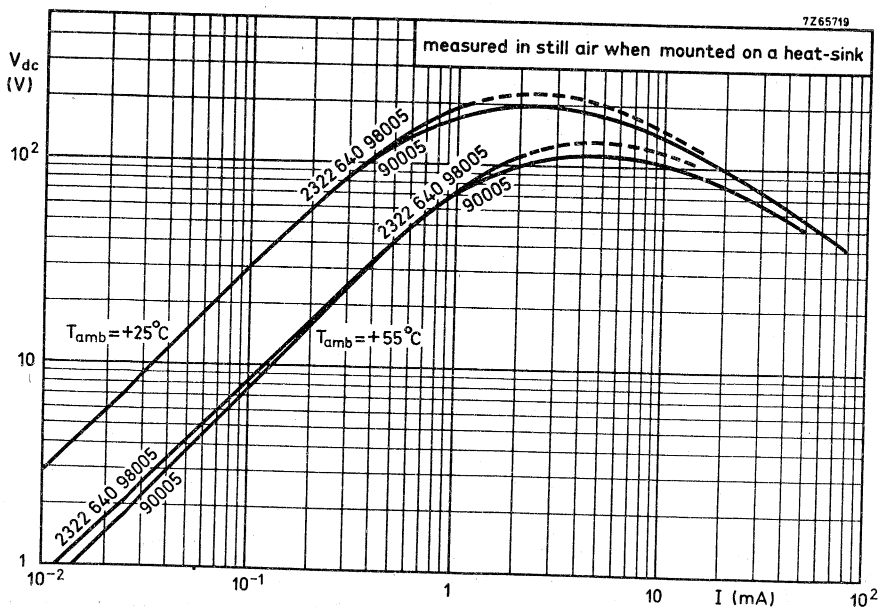


Fig. 3 Typical voltage/current characteristics.

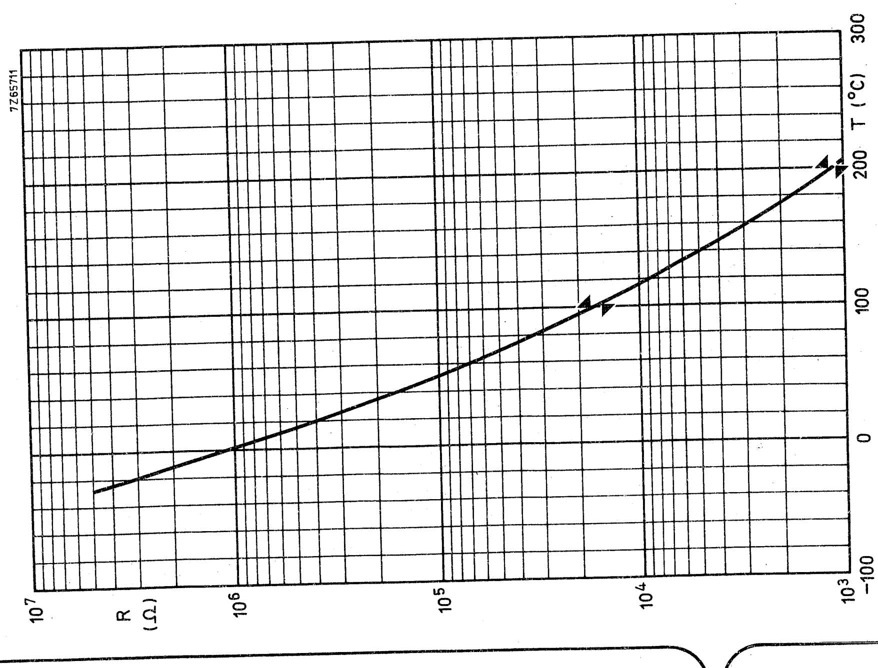


Fig. 4 Typical resistance/temperature characteristics.

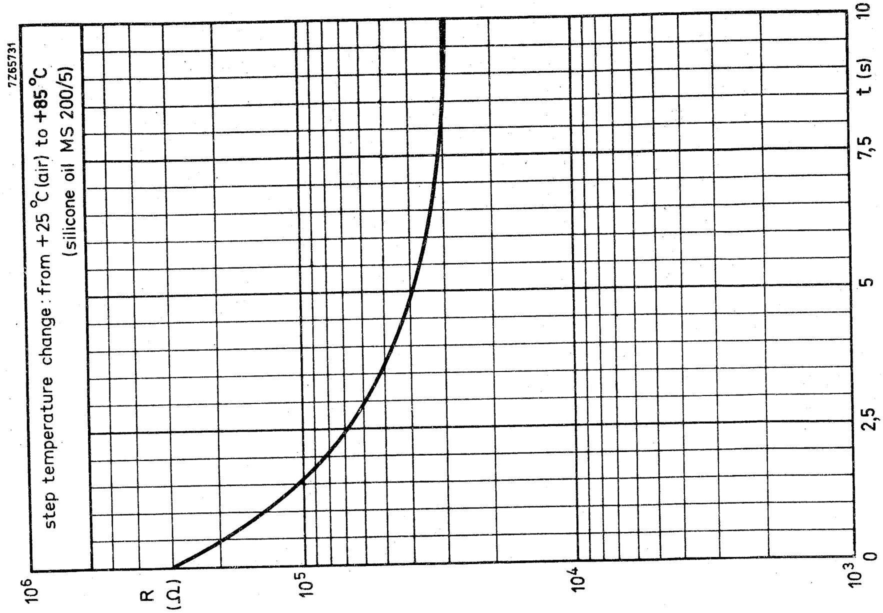


Fig. 5 Typical resistance/response time characteristics.

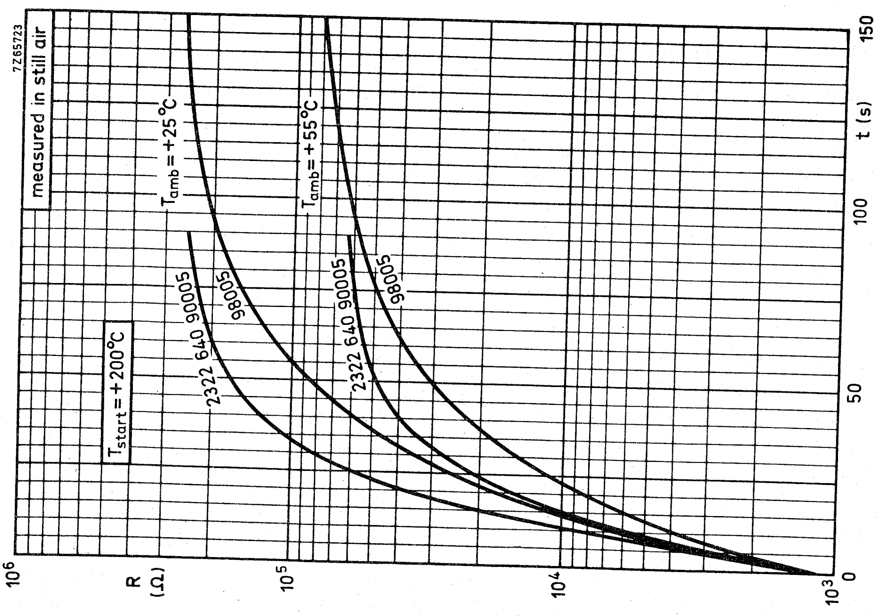


Fig. 6 Typical resistance/time (cooling) characteristics.

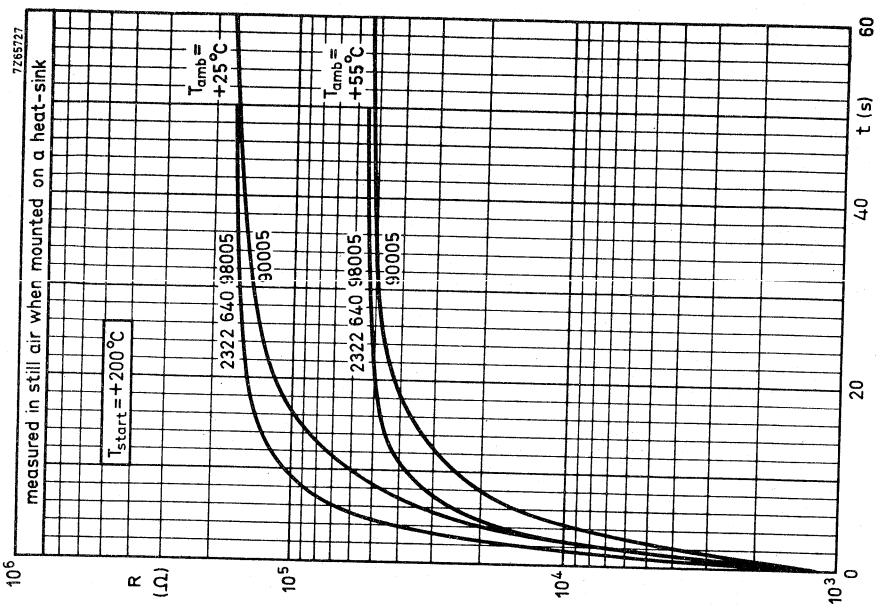


Fig. 7 Typical resistance/time (cooling) characteristics.

NTC THERMISTORS

QUICK REFERENCE DATA

	2322 640 90007	2322 640 90021
Resistance value		
at +25 °C	12 kΩ ± 7%	12 kΩ ± 5,5%
at +90 °C	1,3 kΩ ± 5%	1,3 kΩ ± 3,5 kΩ
$B_{25/85}$-value	3700 K	
Maximum dissipation	0,25 W	
Dissipation factor		
in still air	7,5 mW/K	
in still water	18 mW/K	
Thermal time constant in still air	285 s	
Operating temperature range		
at zero power, continuously	−25 to +110 °C	
for max. 24 h	to +130 °C	
at maximum power	0 to +55 °C	

APPLICATION

As a temperature sensor for water temperature control in washing machines, dish washers, etc.

DESCRIPTION

Disc thermistor with negative temperature coefficient, mounted in a capsule of stainless steel, with two tinned brass spade connectors.

MECHANICAL DATA

Outlines

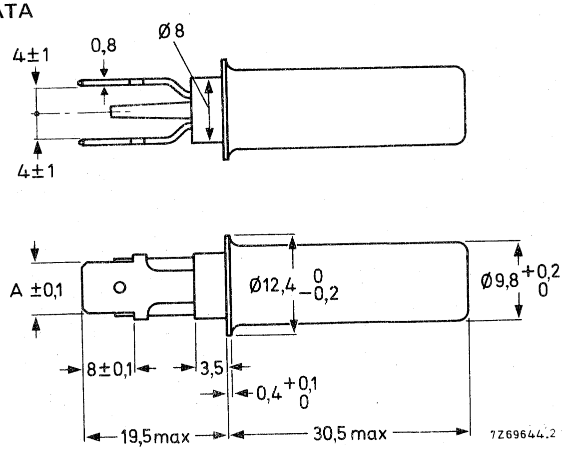


Fig. 1.

A = 6,3 mm for thermistor 2322 640 90007
A = 2,8 mm for thermistor 2322 640 90021

Marking	None
Mass	8 g approximately
Mounting	In any position
Robustness of terminations	
Tensile strength	50 N
Impact	
Free fall	1 m
Inflammability	Uninflammable

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance at	
+25 °C	12 kΩ ± 7%
+90 °C	1,3 kΩ ± 5%
$B_{25/85}$-value	3720 K
Temperature coefficient	−4,2 %/K
Maximum dissipation	0,25 W
Dissipation factor	
in still air	7,5 mW/K
in still water	18 mW/K
Thermal time constant in still air	285 s
Response time *	11 s
Temperature gradient **	0,02 K/K
Operating temperature range	
at zero power	min. −25 °C
continuously	max. +110 °C
max. 24 h	max. +130 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage (r.m.s.) between terminals and capsule for 1 minute	min. 1500 V
Insulation resistance between terminals and capsule at 100 V (d.c.)	min. 100 MΩ

PACKAGING

50 thermistors in a cardboard in box.

* The thermistor being transferred from ambient air of +25 °C to water of +100 °C.

** The temperature gradient is the difference between the liquid (water) temperature and the temperature measured by the sensor per degree difference between liquid and connector temperatures. This difference is caused by the heat conduction through the connectors. Measuring circuit is shown in Fig. 2.

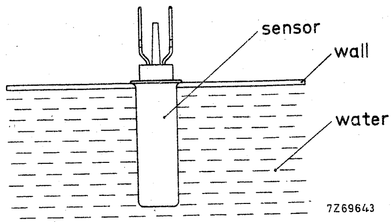


Fig. 2.

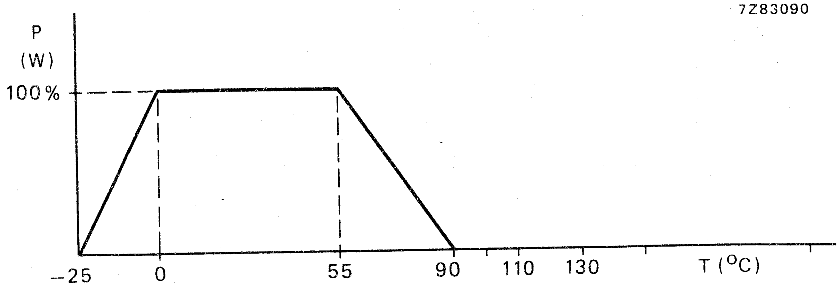


Fig. 3 Power derating with ambient temperature.

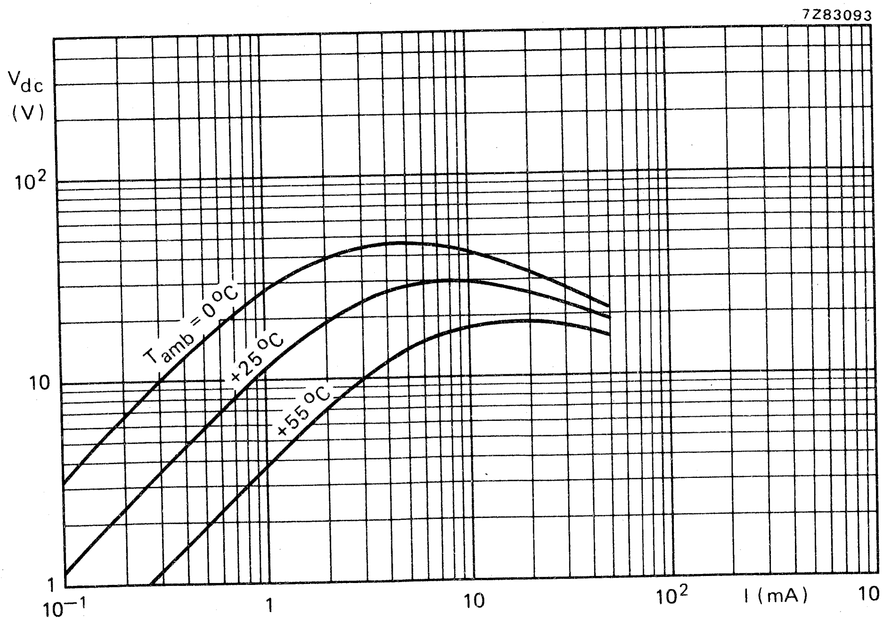


Fig. 4 Typical voltage/current characteristic measured in still air.

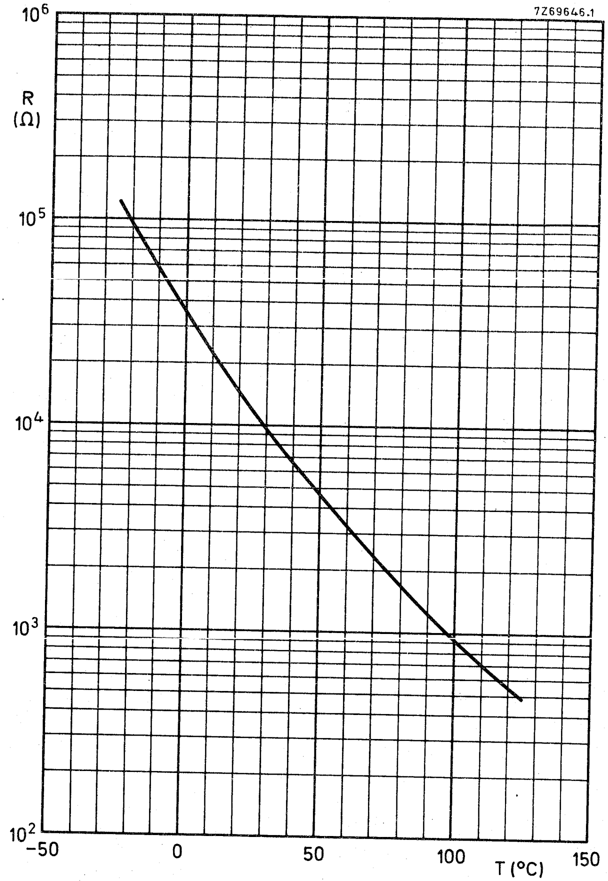


Fig. 5 Typical resistance/temperature characteristic.

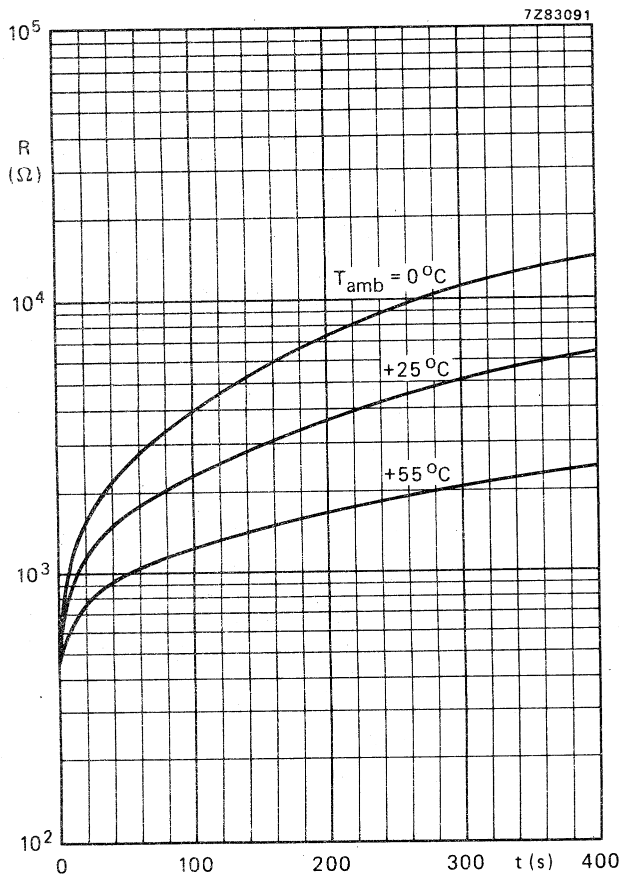


Fig. 6 Typical resistance/time (cooling) characteristics measured in still air, T_{start} = +125 °C.

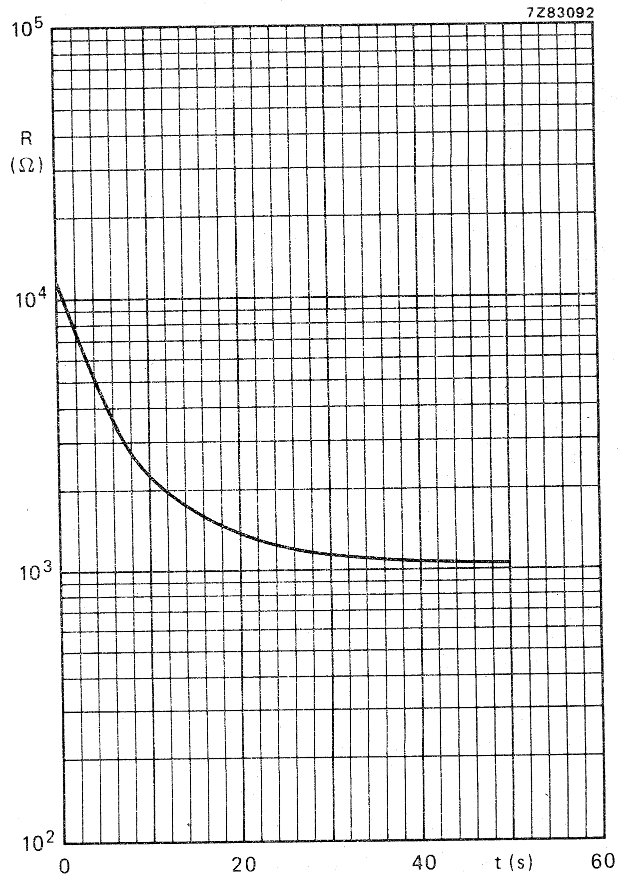


Fig. 7 Typical resistance/response time characteristic. Temperature step from still air of +25 °C to still water of +100 °C.

NTC THERMISTOR

QUICK REFERENCE DATA

Resistance value	
at −30 ± 1,5 °C	50 kΩ
at −20 ± 1,5 °C	27 kΩ
at −10 ± 1,5 °C	15 kΩ
$B_{25/85}$-value	4000 K
Maximum dissipation	0,25 W
Dissipation factor	7,5 mW/K
Thermal time constant	19 s
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C

APPLICATION

For temperature control in deep-freezers.

DESCRIPTION

The thermistor has a negative temperature coefficient. It consists of a disc with two solid tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Outlines

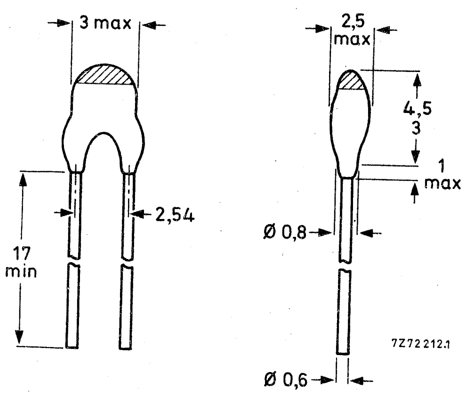


Fig. 1.

Marking

The thermistor is marked with a brown band on top of the body.

Mass

0,14 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

Impact

Free fall	1 m

Uninflammable

Resistant to cleaning solvents

PACKAGING

500 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance value	
at −30 ± 1,5 °C	50 kΩ
at −20 ± 1,5 °C	27 kΩ
at −10 ± 1,5 °C	15 kΩ
$B_{25/85}$-value	4000 K approx.
Temperature coefficient at +25 °C	−4,5 %/K approx.
Maximum dissipation at T_{amb} = +55 °C	0,25 W
Dissipation factor	7,5 mW/K approx.
Thermal time constant (τ_c)	19 s approx.
Heat capacity	0,135 J/K approx.
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C

For typical resistance/temperature characteristic, see page C107

NTC THERMISTORS

moulded

QUICK REFERENCE DATA

	2322 640 90013	2322 640 98013	
Resistance value			
at $-30 \pm 1,5$ °C	50	50	kΩ
at $-20 \pm 1,5$ °C	27	27	kΩ
at $-10 \pm 1,5$ °C	15	15	kΩ
$B_{25/85}$-value	4000	4000	K
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/K
when mounted on a heatsink	16	21	mW/K
Thermal time constant	17	32	s
when mounted on a heatsink	6	3	s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +55	−55 to +55	°C

APPLICATION

For temperature control in deep-freezers.

DESCRIPTION

Dark grey moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires. The thermistor 2322 640 98013 has a metal strip for mounting.

MECHANICAL DATA

Outlines

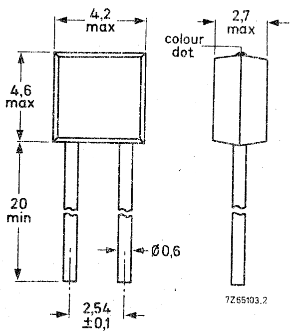


Fig.1 Type 2322 640 90013.

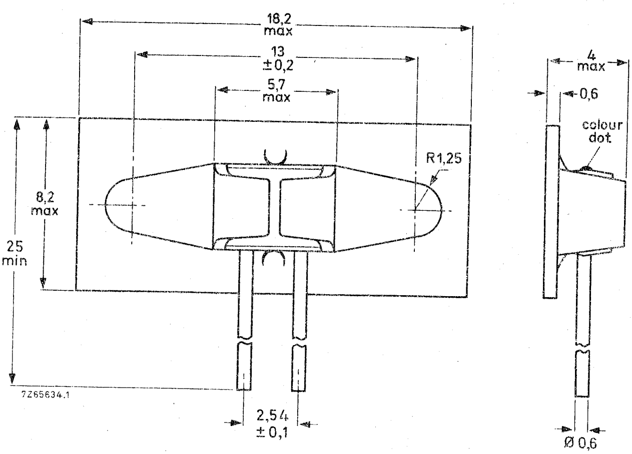


Fig.2 Type 2322 640 98013 with metal strip for mounting.

Marking

The thermistors have a brown dot.

Mass

Type 2322 640 90013	0,3 g approx.
Type 2322 640 98013	0,5 g approx.

Mounting

Type 2322 640 90013	in any position by soldering
Type 2322 640 98013	by means of the mounting strip

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, solder bath 5 mm from body

Impact

Free fall	1 m

Inflammability

Uninflammable

PACKAGING

Type 2322 640 90013: 500 thermistors in a cardboard box.
Type 2322 640 98013: 400 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

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

	2322 640 90013	2322 640 98013	
Resistance value			
at −30 ± 1,5 °C	50	50	kΩ
at −20 ± 1,5 °C	27	27	kΩ
at −10 ± 1,5 °C	15	15	kΩ
$B_{25/85}$-value	4000	4000	K
Temperature coefficient	−4,5	−4,5	%/K
Maximum dissipation at T_{amb} = +55 °C	0,25	0,25	W
Dissipation factor	6,7	9	mW/K
when mounted on a heatsink *	16	21	mW/K
Thermal time constant (τ_c)	17	32	s
when mounted on a heatsink *	6	3	s
Heat capacity			
of ceramic	0,009	0,009	J/K
of complete component	0,11	0,29	J/K
Response time (τ_r) **	1,3		s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +55	−55 to +55	°C
Dielectric withstanding voltage (r.m.s.) between terminals and coating	min. 350	min. 350	V
Insulation resistance between terminals and coating at 100 V (d.c.)	min. 100	min. 100	MΩ

* The thermistor mounted on a heatsink of 100 cm², thickness 1,5 mm.

** From air of +25 °C to silicone oil (MS 200/5) of −20 °C.

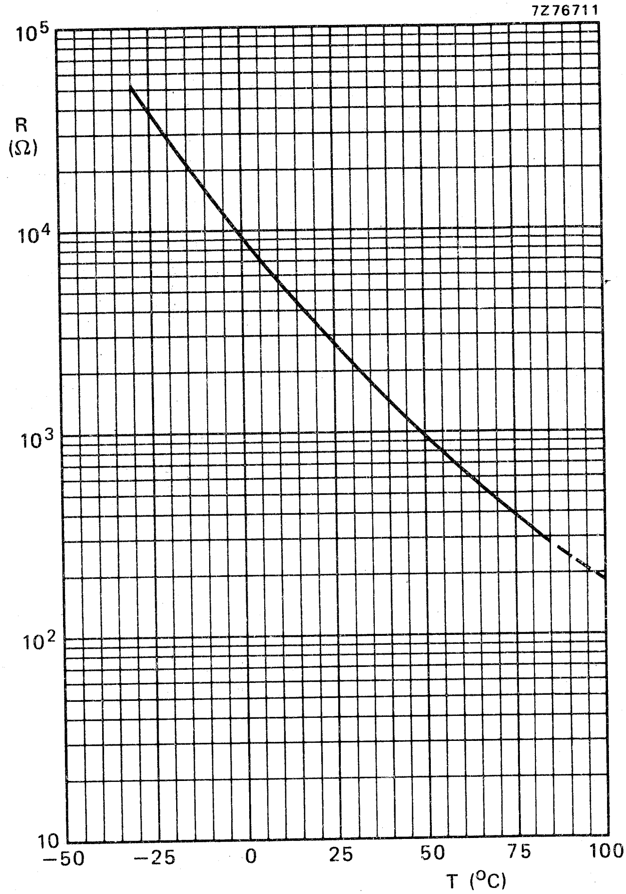


Fig. 3 Typical resistance/temperature characteristic.

NTC THERMISTOR

QUICK REFERENCE DATA

Resistance value	
at −10 ± 1,5 °C	15 kΩ
at +25 ± 1,5 °C	2,7 kΩ
$B_{25/85}$-value	4000 K
Maximum dissipation	0,25 W
Dissipation factor	7,5 mW/K
Thermal time constant	19 s
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C

APPLICATION

For room temperature control.

DESCRIPTION

The thermistor has a negative temperature coefficient. It consists of a disc with two solid tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Outlines

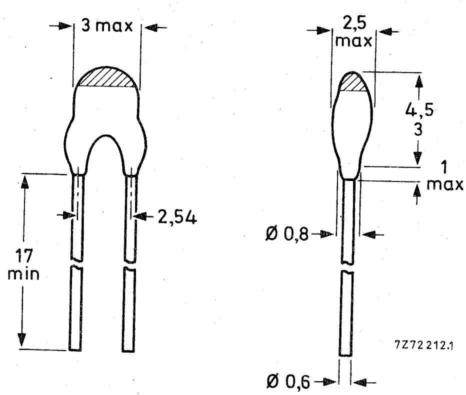


Fig.1.

Marking

The thermistor is marked with a red band on top of the body.

Mass

0,14 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

Impact

Free fall	1 m

Uninflammable

Resistant to cleaning solvents

PACKAGING

500 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance value	
at −10 ± 1,5 °C	15 kΩ
at +25 ± 1,5 °C	2,7 kΩ
$B_{25/85}$-value	≈ 4000 K
Temperature coefficient at +25 °C	≈ −4,5 %/K
Maximum dissipation at T_{amb} = +55 °C	0,25 W
Dissipation factor	≈ 7,5 mW/K
Thermal time constant (τ_c)	≈ 19 s approx.
Heat capacity	≈ 0,135 J/K
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C

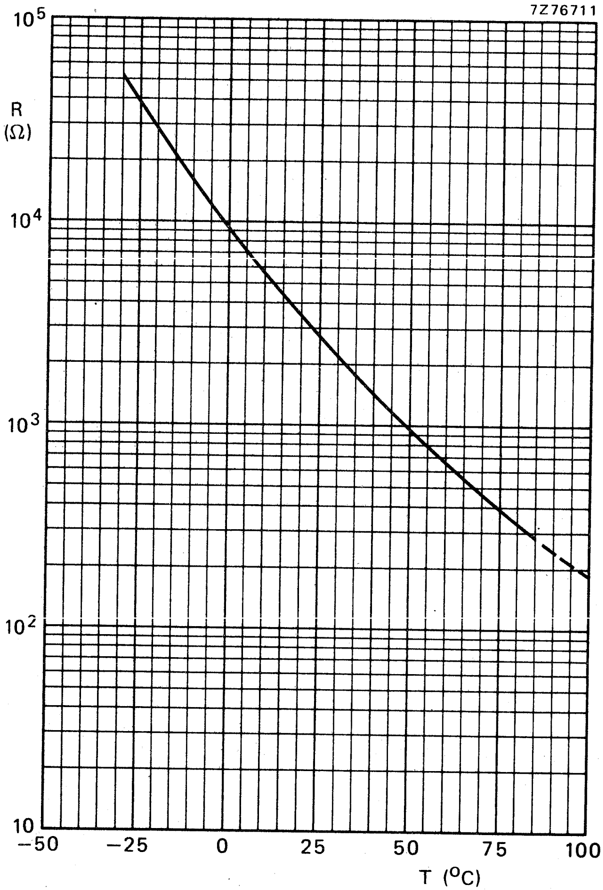


Fig.2 Typical resistance/temperature characteristic.

NTC THERMISTORS

moulded

QUICK REFERENCE DATA

	2322 640 90015	2322 640 98015	
Resistance value			
at −10 ± 1,5 °C	15	15	kΩ
at +25 ± 1,5 °C	2,7	2,7	kΩ
$B_{25/85}$-value	4000	4000	K
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/K
when mounted on a heatsink	16	21	mW/K
Thermal time constant	17	32	s
when mounted on a heatsink	6	3	s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +55	−55 to +55	°C

APPLICATION

For room temperature control.

DESCRIPTION

Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires. Body dark grey.
The thermistor 2322 640 98015 has a metal strip for mounting.

MECHANICAL DATA

Outlines

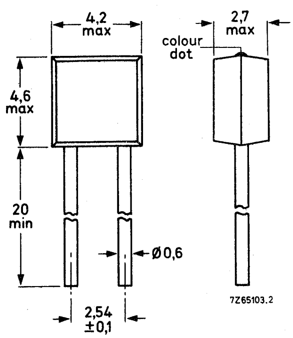


Fig.1 Type 2322 640 90015.

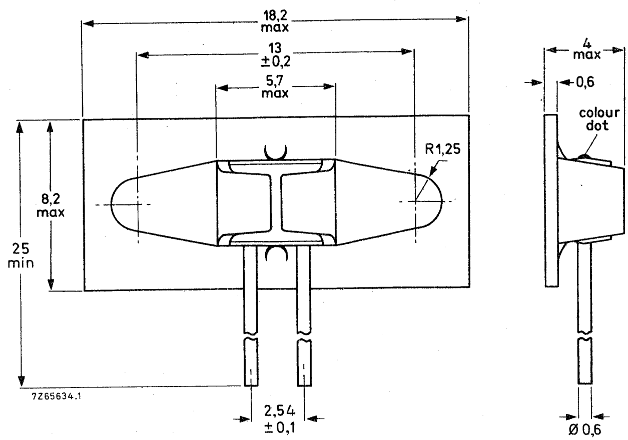


Fig.2 Type 2322 640 98015 with metal strip for mounting.

Marking

The thermistors have a red dot.

Mass

Type 2322 640 90015	0,3 g approx.
Type 2322 640 98015	0,5 g approx.

Mounting

Type 2322 640 90015	in any position by soldering
Type 2322 640 98015	by means of the mounting strip

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, solder bath 5 mm from body

Impact

Free fall	1 m

Inflammability

Uninflammable

PACKAGING

Type 2322 640 90015: 500 thermistors in a cardboard box.
Type 2322 640 98015: 400 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

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

	2322 640 90015	2322 640 98015	
Resistance value			
at −10 ± 1,5 °C	15	15	kΩ
at +25 ± 1,5 °C	2,7	2,7	kΩ
$B_{25/85}$-value	4000	4000	K
Temperature coefficient	−4,5	−4,5	%/K
Maximum dissipation at T_{amb} = +55 °C	0,25	0,25	W
Dissipation factor	6,7	9	mW/K
when mounted on a heatsink *	16	21	mW/K
Thermal time constant (τ_c)	17	32	s
when mounted on a heatsink *	6	3	s
Heat capacity			J/K
of ceramic	0,009	0,009	J/K
of complete component	0,11	0,29	J/K
Response time (τ_r) **	1,3		s
Operating temperature range			
at zero power	−55 to +85	−55 to +85	°C
at maximum power	−55 to +55	−55 to +55	°C
Dielectric withstanding voltage (r.m.s.) between terminals and coating	min. 350	min. 350	V
Insulation resistance between terminals and coating at 100 V (d.c.)	min. 100	min. 100	MΩ

* The thermistor mounted on a heatsink of 100 cm², thickness 1,5 mm.
** From air of +25 °C to silicone oil (MS 200/5) of −20 °C.

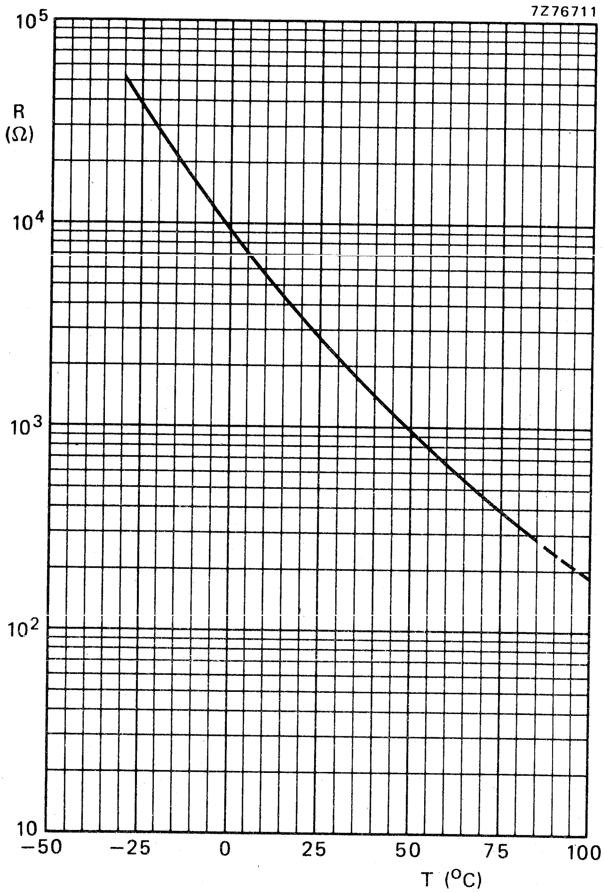


Fig.3 Typical resistance/temperature characteristic.

NTC THERMISTOR

disc

QUICK REFERENCE DATA

Resistance value at + 25 °C	3,3 Ω to 470 kΩ (E6 series)
$B_{25/85}$ value	2675 to 4650 K
Maximum dissipation	0,5 W
Dissipation factor	8,5 mW/K
Thermal time constant	≈ 17 s
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

APPLICATION

Intended for general use.

DESCRIPTION

The thermistor has a negative temperature coefficient, it consists of a disc with two tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Outlines

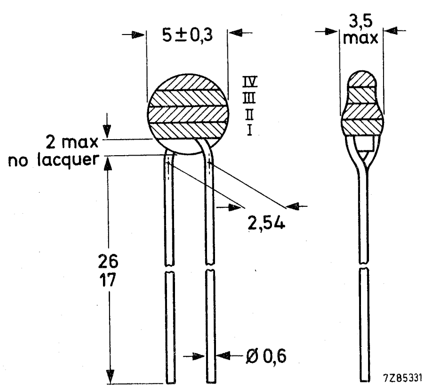


Fig. 1.

PACKAGING

500 thermistors in a cardboard box.

Marking

The thermistors are marked with three or four colour bands in accordance with Fig. 1 and Table 1.

Mass

0,25 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	260 ± 5 °C, 10 ± 1 s

Impact

Free fall	1 m

Flammability

Not inflammable according to IEC as described by TC50 (1979), needle flame.

Resistance to solvents

Resistant to Freon TMC and trichlorotrifluoroethane (70%) + isopropyl alcohol (30%).

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance at 25 °C	see Table 1
$B_{25/85}$ values	see Table 1
Temperature coefficient	see Table 1
Maximum dissipation	0,5 W
Dissipation factor	$\delta \approx$ 8,5 mW/K
Thermal time constant	$\tau_c \approx$ 17 s
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power, see Fig. 2	0 to + 55 °C

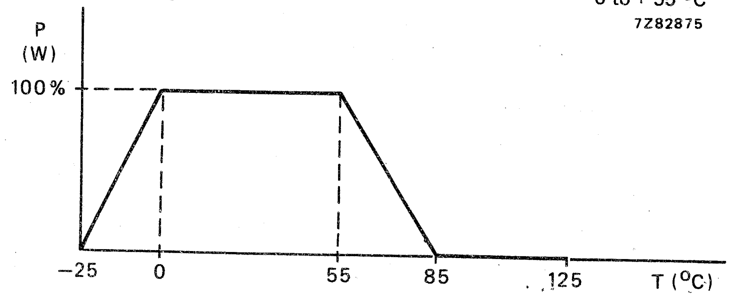


Fig. 2 Derating curve.

Table 1 Catalogue number 2322 642 6....

suffix of catalogue number	R_{25} Ω	$B_{25/85}$ K	temperature coefficient %/K	colour code (see Marking) I	II	III	* IV
.338	3,3	2675	–3,0	orange	orange	gold	
.478	4,7	2750	–3,1	yellow	violet	gold	
.688	6,8	2800	–3,2	blue	grey	gold	
.109	10	2875	–3,2	brown	black	black	
.159	15	2950	–3,3	brown	green	black	
.229	22	3025	–3,4	red	red	black	
.339	33	3100	–3,5	orange	orange	black	
.479	47	3150	–3,5	yellow	violet	black	
.689	68	3225	–3,6	blue	grey	black	
.101	100	3300	–3,7	brown	black	brown	
.151	150	3375	–3,8	brown	green	brown	
.221	220	3475	–3,9	red	red	brown	
.331	330	3575	–4,0	orange	orange	brown	
.471	470	3650	–4,1	yellow	violet	brown	
.681	680	3725	–4,2	blue	grey	brown	
.102	1 000	3825	–4,3	brown	black	red	
.152	1 500	3975	–4,5	brown	green	red	
.222	2 200	4125	–4,6	red	red	red	
.332	3 300	4250	–4,8	orange	orange	red	
.472	4 700	4350	–4,9	yellow	violet	red	
.682	6 800	4400	–5,0	blue	grey	red	
.103	10 000	4275	–4,8	brown	black	orange	
.153	15 000	4200	–4,7	brown	green	orange	
.223	22 000	4275	–4,8	red	red	orange	
.333	33 000	4350	–4,9	orange	orange	orange	
.473	47 000	4400	–5,0	yellow	violet	orange	
.683	68 000	4450	–5,1	blue	grey	orange	
.104	100 000	4500	–5,2	brown	black	yellow	
.154	150 000	4550	–5,2	brown	green	yellow	
.224	220 000	4600	–5,3	red	red	yellow	
.334	330 000	4625	–5,3	orange	orange	yellow	
.474	470 000	4650	–5,4	yellow	violet	yellow	

* Replace dot in catalogue number (9th digit) by:
1 for a tolerance of 20% on R_{25}, there is no colour band IV.
2 for a tolerance of 10% on R_{25}, band IV is silver.
3 for a tolerance of 5% on R_{25}, band IV is gold.

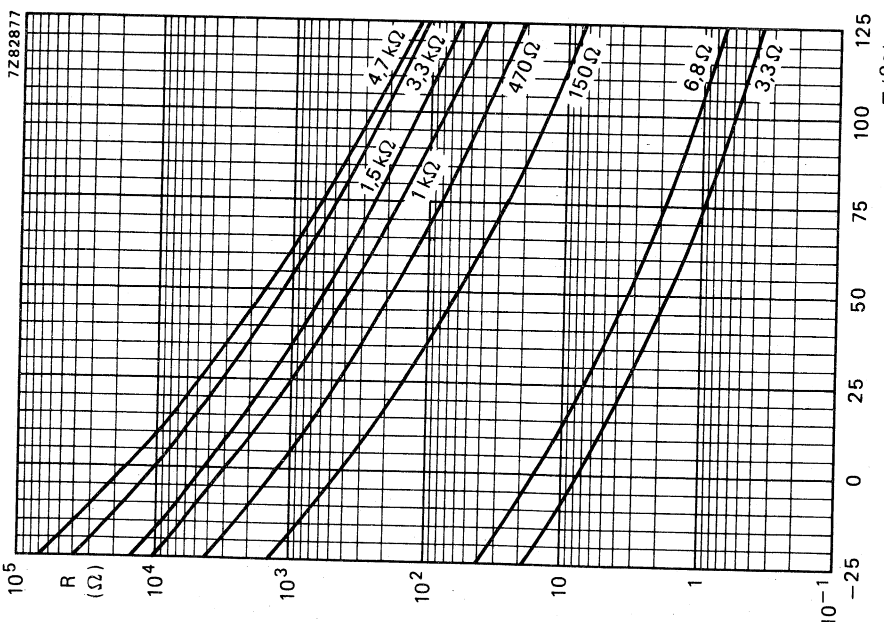


Fig. 3 Typical resistance/temperature characteristic.

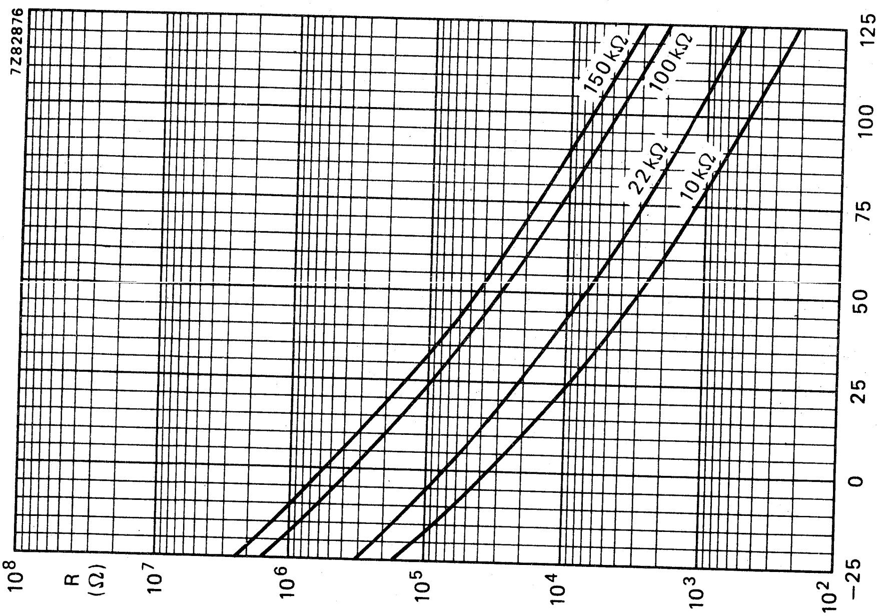


Fig. 4 Typical resistance/temperature characteristic.

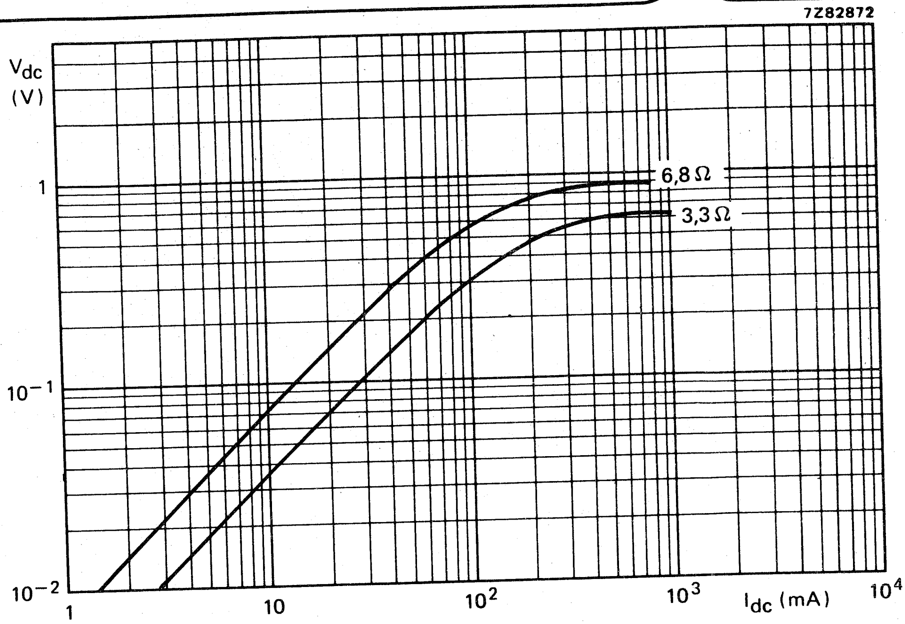


Fig. 5 Typical voltage/current characteristic, T_{amb} = + 25 °C, still air.

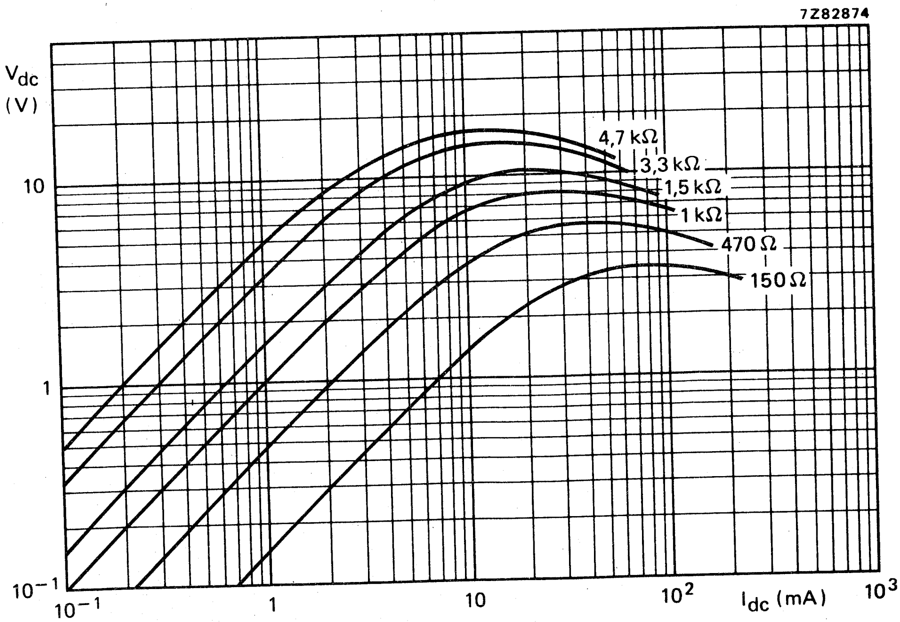


Fig. 6 Typical voltage/current characteristic, T_{amb} = + 25 °C, still air.

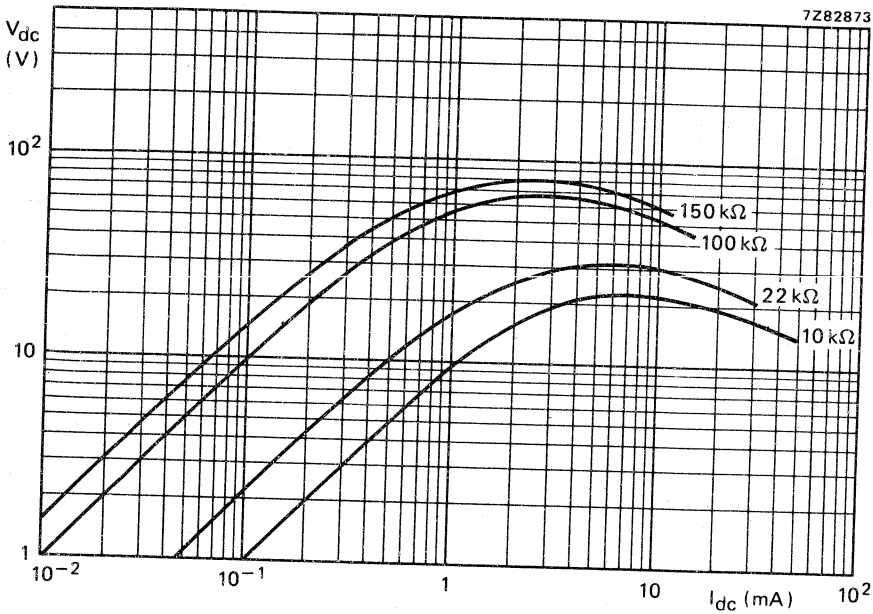


Fig. 7 Typical voltage/current characteristic, T_{amb} = + 25 °C, still air.

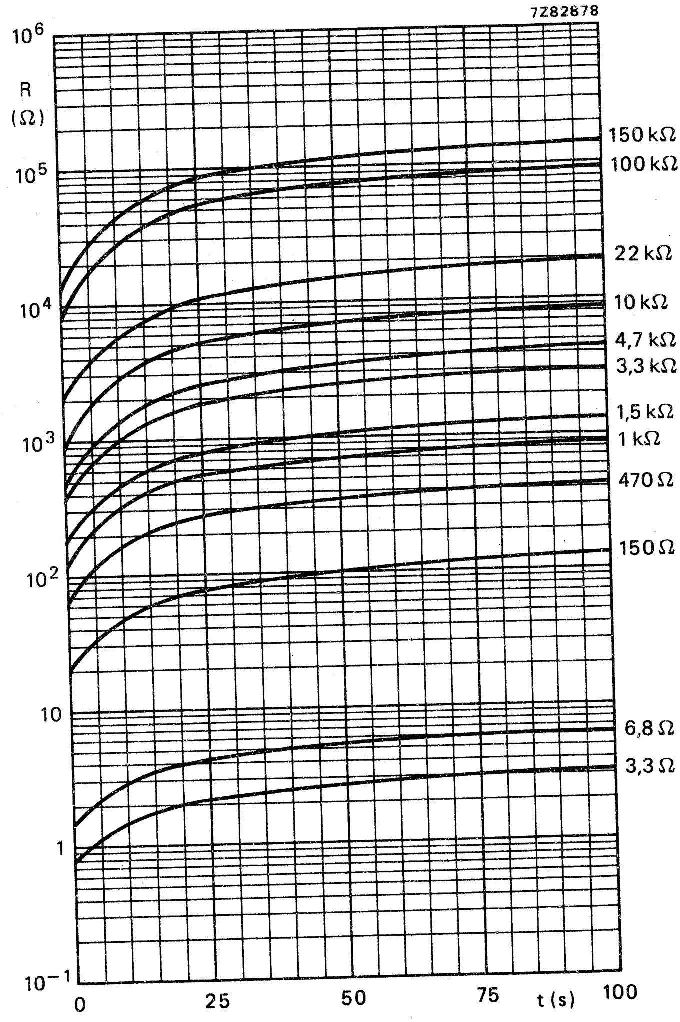


Fig. 8 Typical resistance/cooling time characteristic, T_{amb} = + 25 °C, still air, T_{start} = + 85 °C.

NTC THERMISTORS

with mounting stud

QUICK REFERENCE DATA

Resistance value at + 25 °C	3,3 Ω to 330 kΩ (E6 series)
$B_{25/85}$-value	2675 to 4625 K
Maximum dissipation	0,5 W
Dissipation factor	25 mW/K
Thermal time constant	20 s
Operating temperature range	
at zero power	−25 to + 100 °C
at maximum power	0 to + 55 °C

APPLICATION

Suitable for all kinds of applications, especially when a good insulation and/or a good thermal contact with the chassis is required.

DESCRIPTION

Disc thermistor with negative temperature coefficient mounted in the head of aluminium screws M4 and with two solid tinned copper wires.

MECHANICAL DATA

Outline drawing

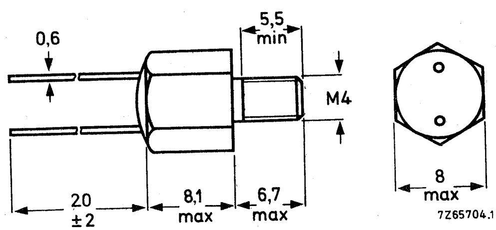


Fig. 1.

Marking

The resistance value at +25 °C (according to table) is printed on the stud in code.
Thermistors with a 5% tolerance have a gold dot; 10% tolerance is identified by a silver dot.

Mass

1,5 g approx.

Mounting

By means of a washer and M4 nut supplied with the device.
Applied torque shall not exceed 1,2 Nm. Leads to be soldered.

Robustness of terminations

Tensile strength	10 N
Bending	5 N
Torque applied on screw	1,2 Nm max.

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

Maximum dissipation	0,5 W
Dissipation factor *	25 mW/K
Thermal time constant *	20 s approx.
Heat capacity	0,5 J/K approx.
Operating temperature range	
at zero power	−25 to +100 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage between terminals and screw	min. 100 V r.m.s.
Insulation resistance between terminals and screw at 100 V d.c.	min. 100 MΩ

See further Table 1.

For typical resistance/temperature and voltage/current characteristics, see pages C118/C120 (type 2322 642 6....).

* Measured when screw mounted on an aluminium heatsink of 100 cm^2, thickness 1,5 mm, in still air, T_{amb} = +25 °C.

Table 1 Catalogue number 2322 642 7....

suffix of catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C
tol. 5%	tol. 10%	Ω	K	%/K
3338	2338	3,3	2675	–2,9
3478	2478	4,7	2750	–3,0
3688	2688	6,8	2800	–3,1
3109	2109	10	2875	–3,2
3159	2159	15	2950	–3,2
3229	2229	22	3025	–3,3
3339	2339	33	3100	–3,4
3479	2479	47	3150	–3,5
3689	2689	68	3225	–3,5
3101	2101	100	3300	–3,6
3151	2151	150	3375	–3,7
3221	2221	220	3475	–3,8
3331	2331	330	3575	–3,9
3471	2471	470	3650	–4,0
3681	2681	680	3725	–4,1
3102	2102	1 000	3825	–4,1
3152	2152	1 500	3975	–4,3
3222	2222	2 200	4125	–4,4
3332	2332	3 300	4250	–4,6
3472	2472	4 700	4350	–4,7
3682	2682	6 800	4400	–4,8
3103	2103	10 000	4275	–5,0
3153	2153	15 000	4200	–4,9
3223	2223	22 000	4275	–4,7
3333	2333	33 000	4350	–4,8
3473	2473	47 000	4400	–4,9
3683	2683	68 000	4450	–4,9
3104	2104	100 000	4500	–5,0
3154	2154	150 000	4550	–5,2
3224	2224	220 000	4600	–5,2
3334	2334	330 000	4625	–5,3

NTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance values at 25 °C	150 Ω, 470 Ω, 1,5 kΩ, 4,7 kΩ	
B-values	between 3500 and 4300 K	
Operating temperature range at zero power	−25 to + 125 °C	
	type 2322 643	type 2322 644
Max. dissipation at 25 °C	1 W	1,5 W
Dissipation factor	10 mW/K	15 mW/K
Thermal time constant	55 s	105 s

APPLICATION

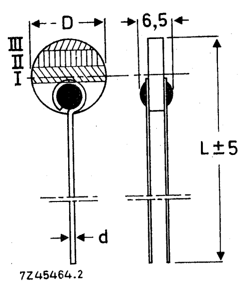
General purpose.

DESCRIPTION

The thermistors have a negative temperature coefficient. They consist of a disc with two tinned copper wires. They are not insulated nor lacquered. The thermistors are colour coded.

MECHANICAL DATA

Outline drawing



series	D	L	d
2322 643	9 ± 0,5	54	0,6
2322 644	15 ± 0,7	60	0,8

Marking

The thermistors are marked with three bands showing their resistance value (R_{25}) in colour code (see Fig. 1); the types with a tolerance on R_{25} of 10% also have a silver band.

Mass

Type 2322 643 ..... 0,9 g approximately.
Type 2322 644 ..... 2 g approximately.

Mounting

In any position by soldering.

PACKAGING

Type 2322 643 ..... 250 thermistors in a cardboard box.
Type 2322 644 ..... 100 thermistors in a cardboard box.

ELECTRICAL DATA

Table 1.

catalogue ** number	R_{25} Ω	$B_{25/85}$-value * K	P_{max} at T_{amb} = 25 °C W	dissipation factor approx. mW/K	thermal time constant approx. s	colour code see Marking I	II	III
2322 643 1.151	150	3500	1	10	55	brown	green	brown
1.471	470	3750	1	10	55	yellow	violet	brown
1.152	1500	4000	1	10	55	brown	green	red
1.472	4700	4200	1	10	55	yellow	violet	red
2322 644 1.151	150	3600	1,5	15	105	brown	green	brown
1.471	470	3900	1,5	15	105	yellow	violet	brown
1.152	1500	4200	1,5	15	105	brown	green	red
1,472	4700	4300	1,5	15	105	yellow	violet	red

Tolerance on resistance value at 25 °C (R_{25}) ± 20 and ± 10% **

Tolerance on B-value ± 5%

Operating temperature range at zero power −25 to + 125 °C

* B-value is subject to change.

** Replace dot in catalogue number (9th digit) by: 1 for a tolerance of 20% on R_{25}.
2 for a tolerance of 10% on R_{25}.

NTC THERMISTORS

disc

QUICK REFERENCE DATA

	2322 644 90004	2322 644 90005
Resistance value at +25 °C	82 Ω ± 20%	min. 15 Ω
Resistance at T_{amb} = +25 °C, and I_{rms} = 1,7 A and 2,2 A respectively	max. 0,85 Ω	max. 1 Ω
$B_{25/85}$-value	4650 K	3350 K
Maximum current (r.m.s.)	1,7 A	2,2 A
Dissipation factor	19 mW/K	17 mW/K
Thermal time constant	115 s	148 s
Operating temperature range		
at zero power	−25 to +155 °C	−25 to +155 °C
at maximum power	0 to +55 °C	0 to +55 °C

APPLICATION

For limiting surge current, e.g. diode and switch protection.

DESCRIPTION

This thermistor has a negative temperature coefficient. It consists of a disc with two tinned copper wires. The thermistor body is neither lacquered nor insulated.

MECHANICAL DATA

Outline drawing

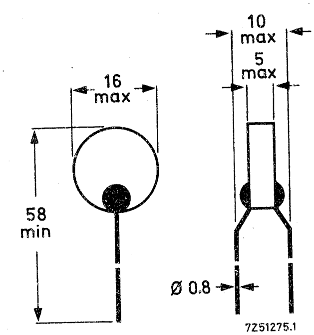


Fig. 1.

Marking

The thermistors are not marked.

Mass

Type 2322 644 90004	approx. 3,2 g
Type 2322 644 90005	approx. 4 g

Mounting

In any position by soldering. Do not solder within 10 mm from the thermistor 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

50 thermistors in a cardboard box.

ELECTRICAL DATA

	2322 644 90004	2322 644 90005	
R at 25 °C	82 ± 20%	min. 15	Ω
R at T_{amb} = 25 °C, I_{rms} = 1,7 A	max. 0,85		Ω
R at T_{amb} = 25 °C, I_{rms} = 2,2 A		max. 1	Ω
$B_{25/85}$-value, approx.	4650	3350	K
Max. current (r.m.s.) at T_{amb} = +55 °C	1,7	2,2	A
Dissipation factor, approx.	19	17	mW/K
Thermal time constant, approx.	115	148	s
Heat capacity, approx.	2,2	2,5	J/K
Operating temperature range			
at zero power	−25 to +155	−25 to +155	°C
at maximum power	0 to +55	0 to +55	°C
Max. repetitive peak voltage 50-60 Hz	345	380	V

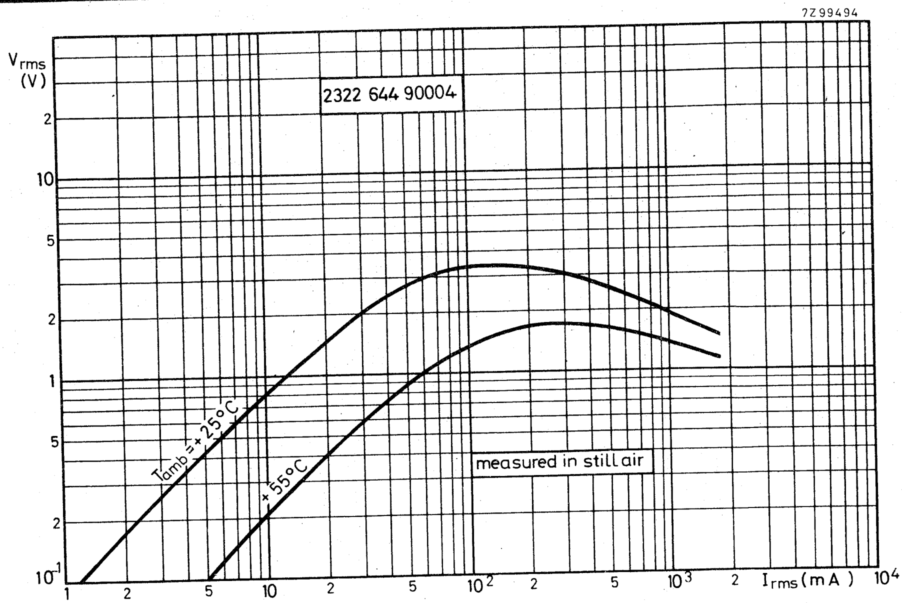


Fig. 2 Typical voltage/current characteristics.

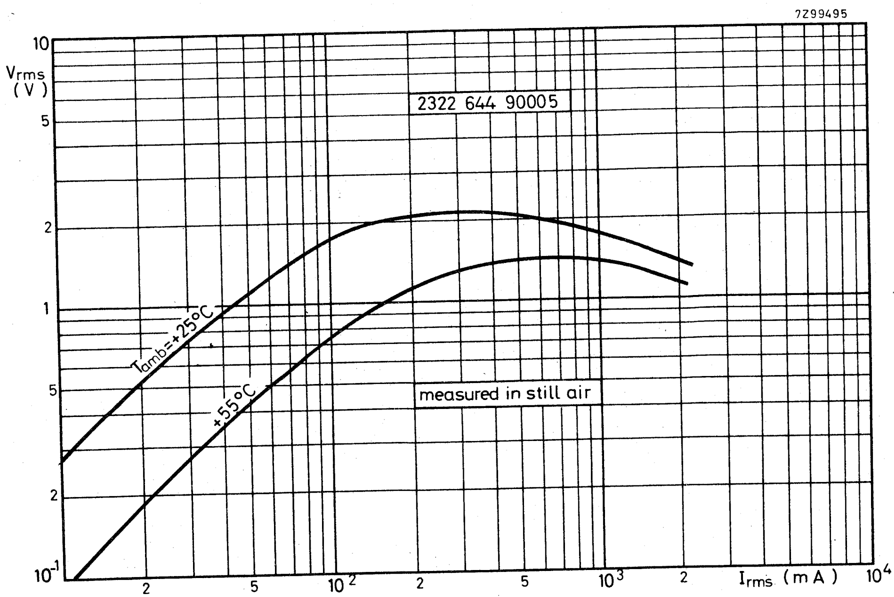


Fig. 3 Typical voltage/current characteristics.

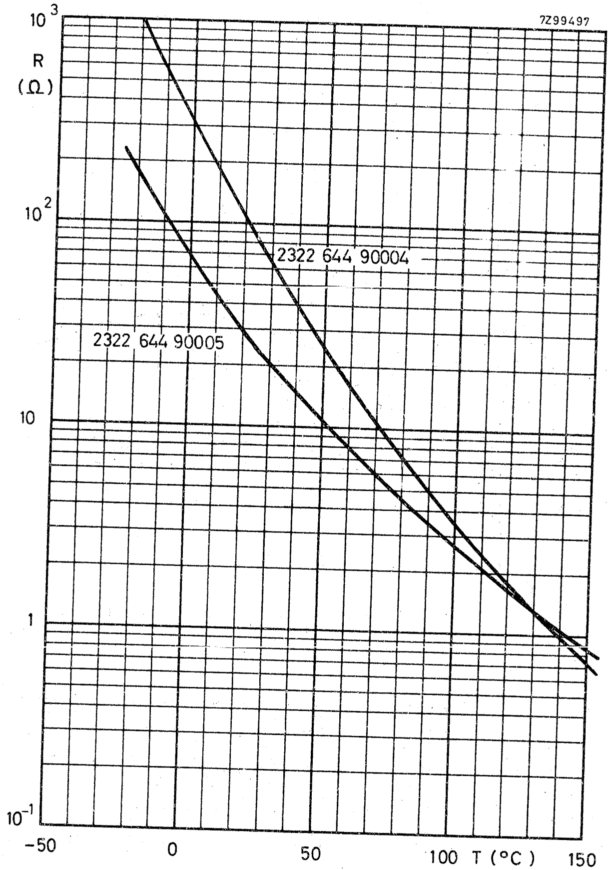


Fig. 4 Typical resistance/temperature characteristics.

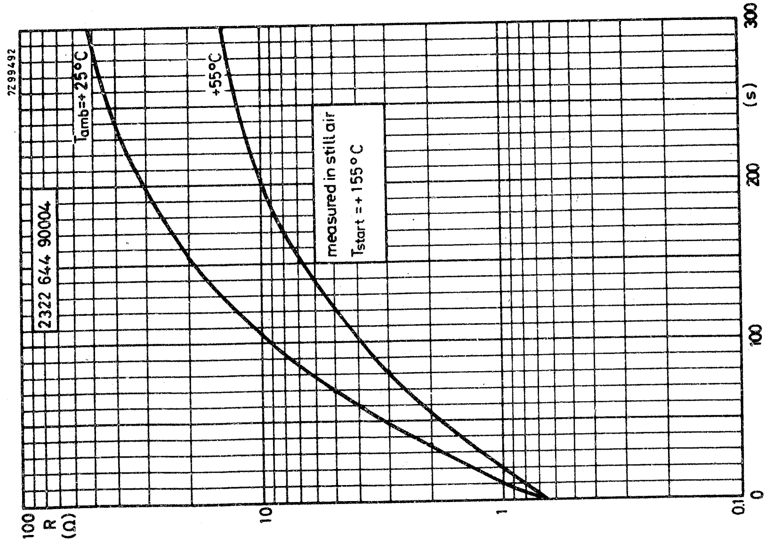


Fig. 6 Typical resistance/time (Cooling) characteristics.

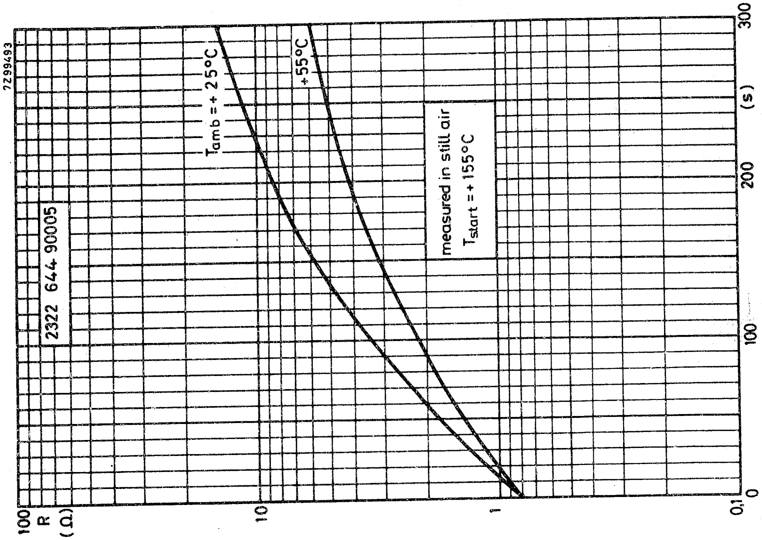


Fig. 7 Typical resistance/time (Cooling) characteristics.

NTC THERMISTOR
disc without leads

QUICK REFERENCE DATA

Resistance value at +25 °C	5 Ω ± 20%
Resistance value at I_{rms} = 2,2 A	max. 0,5 Ω
$B_{25/85}$-value	2975 K
Maximum current (r.m.s.)	8 A
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION
For limitation of surge current.

DESCRIPTION
Disc thermistor with negative temperature coefficient, provided with reinforced contacts.

MECHANICAL DATA
Outline drawing

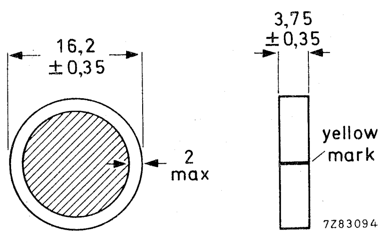


Fig. 1.

Marking	yellow stripe, see Fig. 1.
Mass	4,2 g approximately.
Mounting	In any position by clamping.
Impact	Free fall, 0,1 m.
Inflammability	Uninflammable

PACKAGING
10 preformed sheets of polystyrene containing 75 items in a cardboard box. Resistance value and catalogue number are printed on the box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance value at +25 °C	5 Ω ± 20%
Resistance value at I_{rms} = 2,2 A	max. 0,5 Ω
$B_{25/85}$-value	2975 K
Temperature coefficient	–3,35%/K
Maximum current (r.m.s.)	8 A
Operating temperature range	
at zero power	–25 to +155 °C
at maximum power	0 to +55 °C

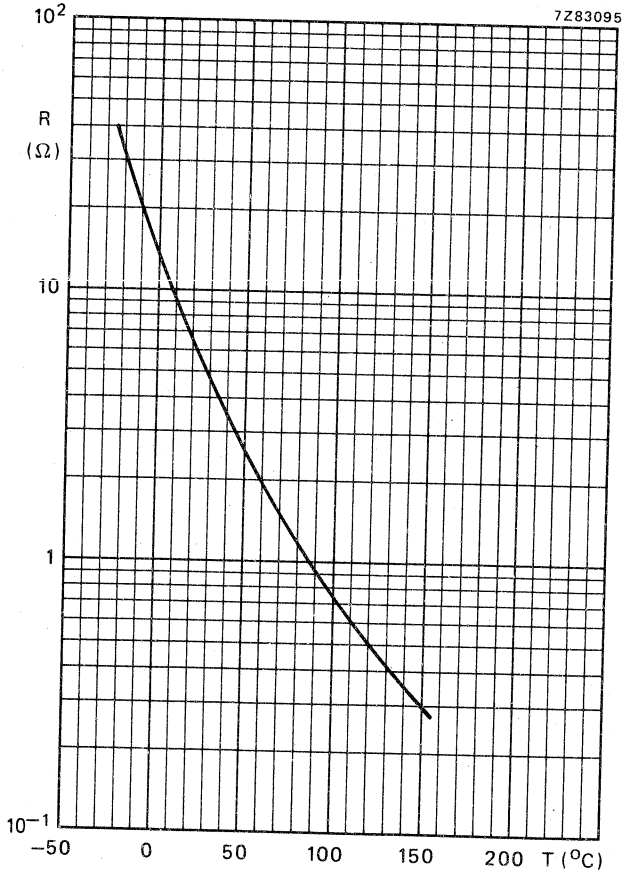
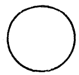
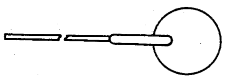
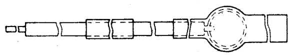
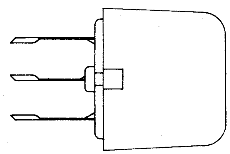
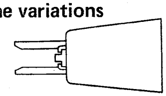
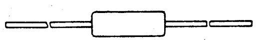
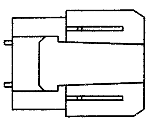


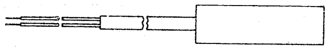
Fig. 2 Typical resistance/temperature characteristic.

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC) D

SURVEY

	maximum voltage	R_{25} Ω	switch temperature °C	dissipation factor mW/K	temperature coefficient %/K	catalogue number
DISC 	300 V (r.m.s.) 400 V (r.m.s.)	8,75 to 17,5 70 to 100	120 105	11,5	35	2322 678 93002 2322 662 93006
DISC with leads 	16 V (d.c.)	⩽ 0,6	85	27	10	2322 664 91086
	25 V (d.c.)	30 to 250	70 to 150	5,7	18 to 38	2322 672 91002 to 2322 672 91035
	25 V (d.c.)	50-60 ± 30%	30 to 105	7	7 to 40	2322 660 91006 to 2322 660 91009
	25 V (d.c.)	250 ± 25%	6	6	5	2322 660 91001
	40-50 V (d.c.)	30 to 50 ± 15 Ω	25 to 110	6-8,5	9 to 75	2322 661 91002 to 2322 661 91005
	180 V (d.c.)	36 to 50	115	13	35	2322 662 91001
	245 V (r.m.s.)	750 to 1500	115	7	26	2322 660 93001
	265 V (r.m.s.)	45 to 60	75	20	20	2322 662 93036
	265 V (r.m.s.)	100 ± 20%	75	15,3	35	2322 662 93066

Overload protection	60 V (d.c. and 245 V r.m.s.)	1,65 to 55 3,7 to 1500	115 115			selection on pages D125-D127
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
Motor protection 	15 V (d.c.)	30 to 250	68 to 137	7	18 to 38	2322 672 92045 to 2322 672 92053
DUAL PTC for degaussing 	245 V (r.m.s.) 265 V (r.m.s.) 140 V (r.m.s.) 265 V (r.m.s.)	25 and 8 30 and 8 10 and 400 to 2400 40 and 1000 to 6000	75 70 and 170	13,5	23 and 25 25 and 25 16 and 20	2322 662 98001 2322 662 98003 2322 662 98013 2322 662 98009
DISC for compensation of telephone line variations 	33 V (d.c.)	115 ± 25	97	3,9	10	2322 672 98001
	34 V (d.c.)	120 ± 30	145		8	2322 670 90003
DISC for motor start 	300 V (r.m.s.)	8,75 to 17,5	120			2322 678 93001

type	voltage range r.m.s. V	max. inrush power W	operating power after 20 min W	time to reach 130 °C min	measured at	catalogue number
HEATING ELEMENT						
	100 to 265	500	–	–	220 V	2322 680 04022
	100 to 265	500	17 ± 20%	max. 7	220 V	2322 680 90019
	100 to 240	500	15 ± 20%	max. 7	220 V	2322 680 90047
	100 to 265	200	15 ± 20%	max. 7	110 V	2322 680 90136

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.

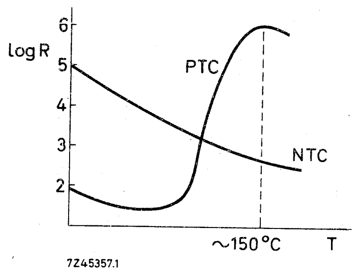
As the PTC effect is caused by crystal boundary barriers the extra resistance R_b is shunted by a high parallel capacitance C_b. This leads to a frequency dependence of extra impedance Z_b up to 5 MHz. The characteristic properties described in the following paragraphs are thus restricted to this frequency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

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

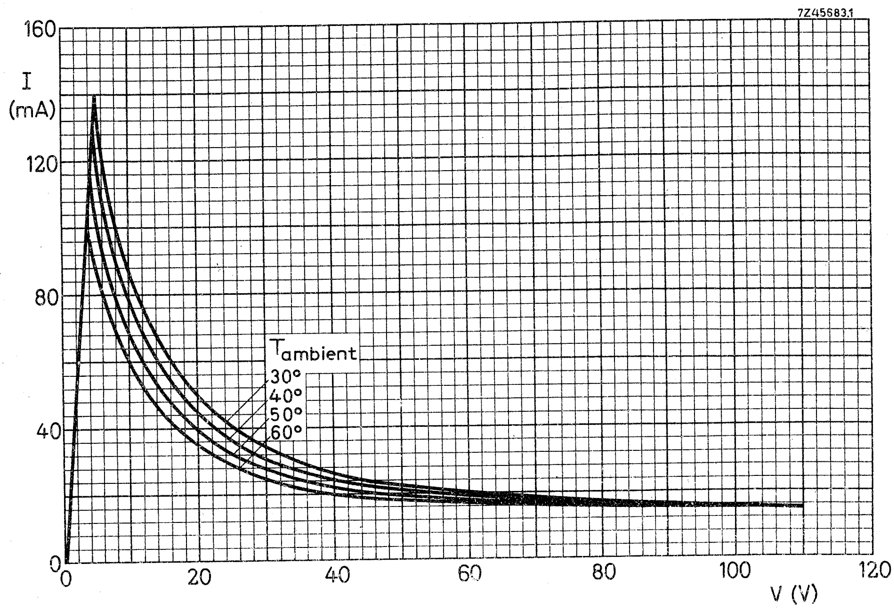


Fig. 2 Voltage/current characteristics of a PTC thermistor on a linear scale, with ambient temperature as a parameter.

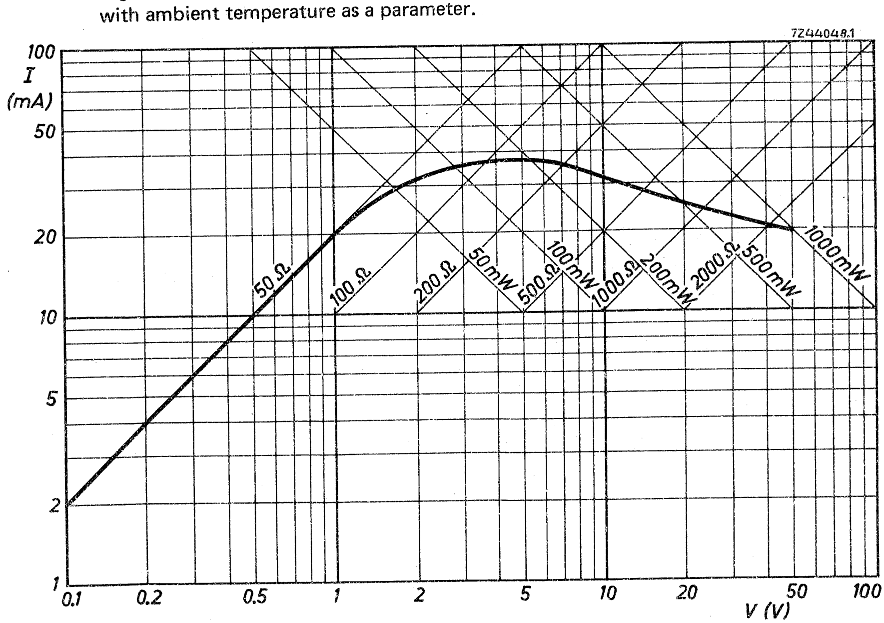


Fig. 3 Voltage/current characteristic on logarithmic scale.

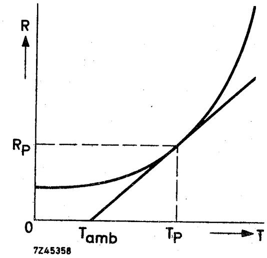


Fig. 4 Part of the resistance/temperature characteristic on a linear scale.

From Fig. 4:

$$\frac{\Delta T_p}{\Delta R_p} = \frac{T_p - T_{amb}}{R_p}$$

so

$$I_p = \sqrt{\frac{D(T_p - T_{amb})}{R_p}}$$

For given ambient temperature (T_{amb}) and D, R_p and T_p can easily be found; see Fig. 4.

The calculation shows that if D is increased n times (e.g. by a heatsink, or ambience with better heat conductivity) I_p increases $\sqrt{n}$ times.

PTC THERMISTOR IN SERIES WITH A LOAD

From the voltage/current characteristic it can be shown that because of the non-linearity of the PTC-curve three working points are possible when a load R is connected in series with the PTC. See Fig. 5. The characteristic of the load is a straight line intersecting the voltage co-ordinate at V_a, the supply voltage. P_1 and P_2 are stable working points; P_3 is unstable.
When the voltage V_a is applied to the series connection, equilibrium will be reached at P_1, a point with a relatively high current. P_2 can only be reached when the top of the V/I curve comes below the load characteristic. This may happen in the following cases:

- V_a increases, see Fig. 6;
- the ambient temperature increases, see Fig. 7;
- the load resistance decreases, see Fig. 8.

The PTC thermistor is thus an excellent protector, limiting the load to a safe value if supply voltage, temperature or current exceeds a critical value.

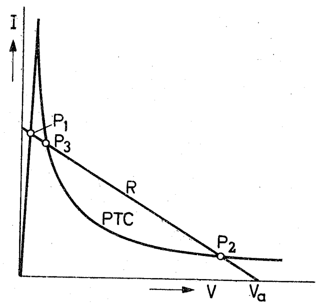


Fig. 5 PTC thermistor in series with a load showing the possible working points.

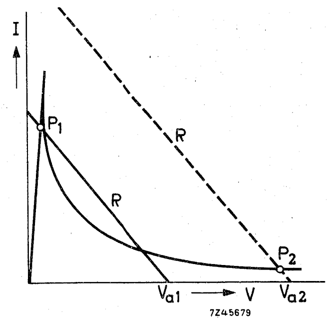


Fig. 6 PTC thermistor in series with a load showing the influence of the supply voltage V_a.

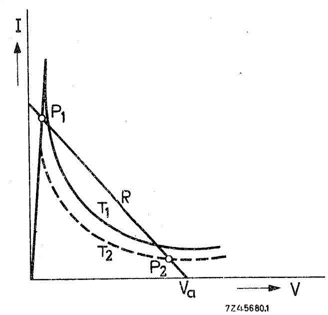


Fig. 7 PTC thermistor in series with a load showing the influence of the ambient temperature.

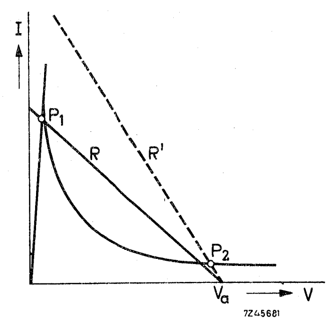


Fig. 8 PTC thermistor in series with a load showing the influence of the load resistance.

CURRENT/TIME CHARACTERISTICS

If a PTC thermistor is connected in series with a resistance of such a value that the top of the V/I curve lies under the load line, the PTC will heat up till the stable working point P_2 is reached (Fig. 9). The time it takes to reach this point depends very much on the value of the load R (Fig. 10) and the ambient temperature.

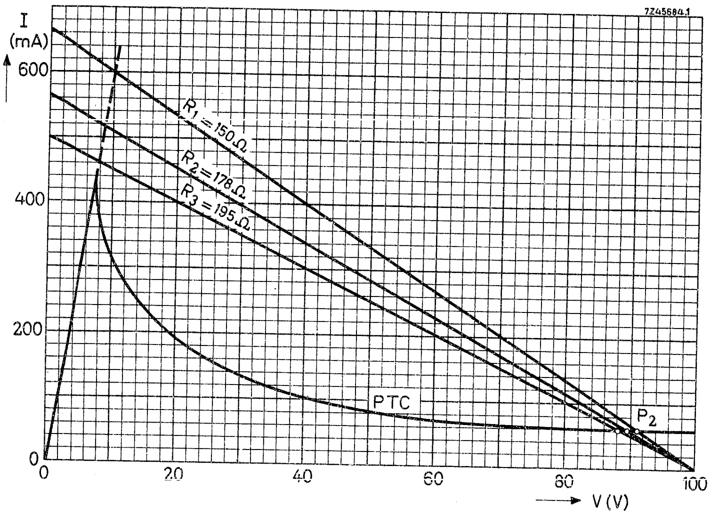


Fig. 9 PTC thermistors in series with different resistors.

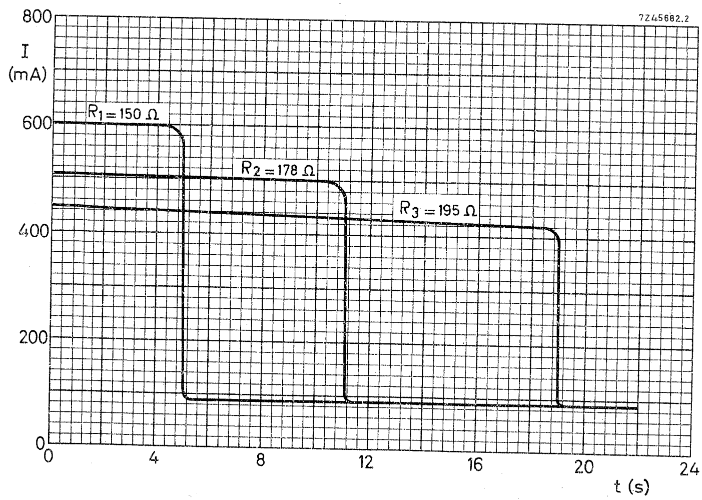


Fig. 10 Current/time characteristics showing the influence of the load.

EXPLANATION OF TERMS

Switch temperature (T_s)

The switch temperature T_s is the higher of the two temperatures at which the resistance R_s is twice the minimum resistance R_{min} (see Fig. 11).
So, at $T_s > T_{Rmin}$: $R_s = 2\ R_{min}$.

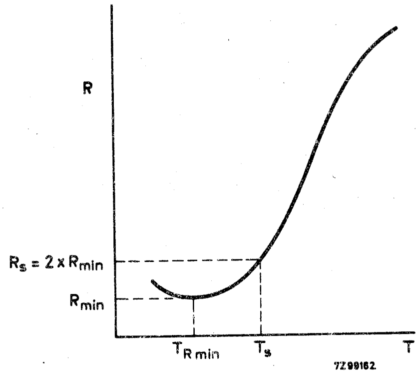


Fig. 11.

Temperature coefficient (α)

The temperature coefficient $\alpha = \frac{1}{R} \frac{dR}{dT}$.

For R-T curves plotted on a log R-lin T scale:

$$\alpha = \frac{d\ ln\ R}{dT} = \frac{1}{0{,}4343} \cdot \frac{d\ log\ R}{dT}$$

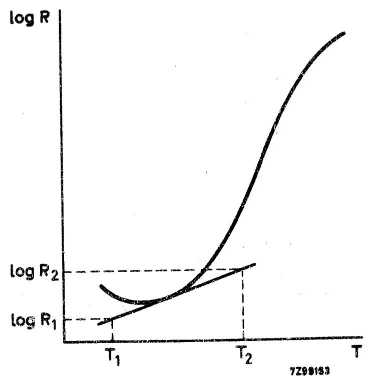


Fig. 12.

α can be calculated from

$$\alpha = \frac{100}{0{,}4343} \cdot \frac{log\ R_2 - log\ R_1}{T_2 - T_1}\ \%/K$$

where R_1 and R_2 are points on the tangent and T_1 and T_2 are the corresponding temperatures.

In the data sheets the maximum temperature coefficient is given, this is the α measured at the point of inflection of the log R-lin T characteristic, i.e. the point where $\frac{d^2 \log R}{dT^2} = 0$, see Fig. 13.

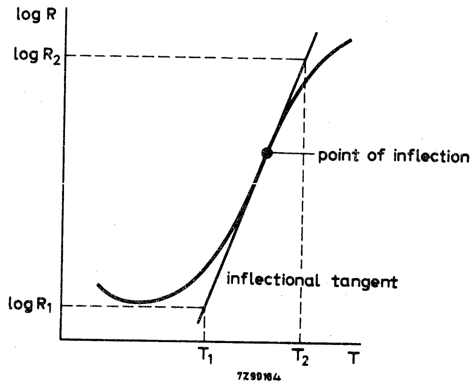


Fig. 13.

When one resistance decade is taken ($R_2 = 10\ R_1$) the formula reduces to

$$\alpha = \frac{100}{0{,}4343} \cdot \frac{1}{T_2 - T_1}\ \%/K$$

Thermal time constant (τ)

The thermal time constant represents the time required for a thermistor to change 63,2% of the total difference between its initial and final body temperatures when subjected to a step function change in temperature under zero-power conditions.
The τ given in the data is found as follows (for $T_s > 25\ ^oC$):
Measure T_1, the temperature of the PTC at V_{max}, at an ambient temperature of $T_o = 25\ ^oC$; T_s is known, so τ can be calculated from:

$$\tau = \frac{t}{\ln\ (T_1 - T_o)/(T_s - T_o)},$$

where t is the time required for cooling the PTC from T_1 to T_s in still air at 25 ^oC.

Voltage dependence

PTC thermistors show a voltage dependence. This effect can be explained with the aid of a parallel connection of an "ideal PTC" having no voltage dependence and an "ideal VDR" for which the relation between voltage and currents is:

$$V = C.I^{\beta}$$

See Fig. 14.

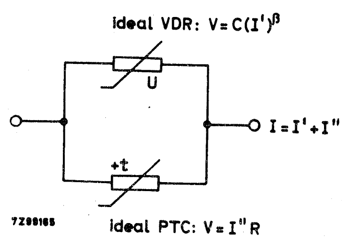


Fig. 14.

Plotted on a log I - log V scale at an arbitrary constant temperature the ideal PTC and the ideal VDR characteristics are straight lines, see Fig. 15.

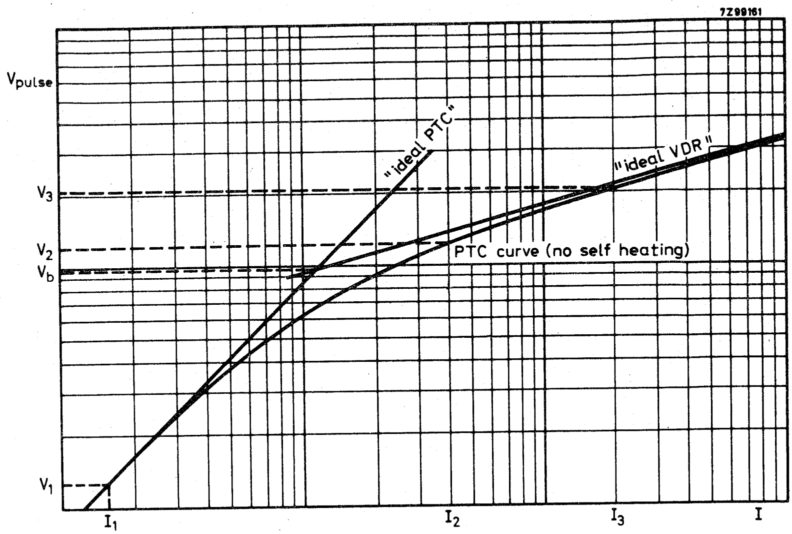


Fig. 15.

These lines coincide with the PTC curve (measured under pulse conditions to avoid internal heating) at low voltages where the ohmic behaviour is the deciding factor, and at high voltages where the VDR effect becomes more significant.
Two aspects of the voltage dependence are specified in the data sheets:

Balance voltage (V_b)

Where the two straight lines intersect, the current through the ideal PTC is equal to the current through the ideal VDR. The voltage at which this occurs is called the balance voltage V_b and is specified at a certain temperature.

Voltage dependence (β)

The β of the ideal VDR is a measure of the voltage dependence of the PTC and can be calculated using the formula:

$$\beta = \frac{\log V_3/V_2}{\log (I_3 - V_3/R)/(I_2 - V_2/R)}$$

where V_3 and V_2 are pulse voltages $> V_b$ and $R = \frac{V_1}{I_1}$, measured at $V_1 \leqslant 1{,}5$ V (d.c.).

β is also specified at a certain temperature.
V_b and β are useful parameters for estimating the voltage dependence of a particular PTC thermistor.

HOW TO MEASURE PTC THERMISTORS

For general information regarding measuring techniques and apparatus refer to the section "How to measure NTC thermistors", which covers the same topics. As PTC thermistors often show a very high temperature coefficient especially at high temperatures, measurements at these high temperatures must be carried out with particular care. Even an error of 0,1 K can give an error in resistance of a few per cent. Specially calibrated thermometers have to be used. Stem correction has to be applied; deviations of more than 0,1 K may result if it is not used.

The stem correction formula for fluid thermometers is:

$$T_c = T_o + F \cdot L\,(T_o - T_m),$$

where: T_c = corrected temperature;
T_o = observed temperature;
T_m = mean temperature of exposed stem;
L = length of the exposed column in K above the surface of the substance whose temperature is being determined;
F = correction factor.

F is approximately 0,00016 for a mercury thermometer.

For example with T_o = 110 °C, T_m = 70 °C and L = 50 K: T_c = 110,32 °C, thus without stem correction an error of more than 0,3 K would have been made. It is also necessary to measure the resistance with a voltage below 2 V in order not to heat the PTC and also to diminish voltage-dependent effects.

TOLERANCES

The resistances of standard PTC thermistors are specified at

(1) 25 °C;
(2) A temperature above the switch temperature.

The switch temperature is also given.

For each standard type tolerances are specified for R_{25} and the high-temperature resistance. The tolerance on switch temperature is not specified; normally it is only a few K.

Special types are often specified according to the requirements for the particular application. The PTC thermistors for motor control, for instance, can be specified at a high temperature with a rather close tolerance, while the tolerance below the switch temperature, being less important, is much greater. PTC thermistors for current limiting applications are in most cases specified in terms of voltage and current.

It will be clear that the specification and the tolerances of PTC thermistors depend on the application, and are not limited to the standard range published in this book.

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.

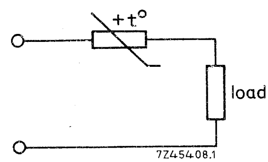
Do not connect PTC thermistors in series in order to obtain higher voltages or wattages: this may cause one PTC to heat up faster than the other(s) resulting in too high a voltage across this particular PTC.

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

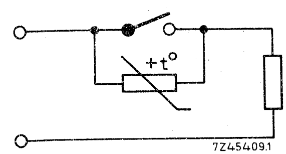
Protection against over-load or current sensitive switching

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



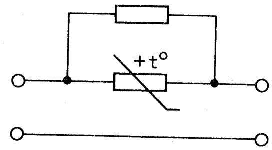
Spark suppression

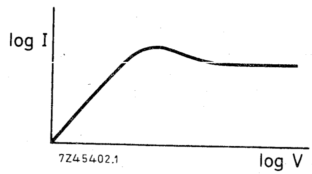
A PTC across the switch acts as a spark suppressor. When the switch opens the low resistance of the cold PTC prevents sparking.



Current stabilization

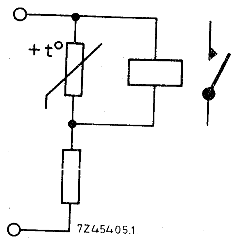
By using a parallel resistor a current stabilization circuit is obtained that compensates slowly varying supply voltages.





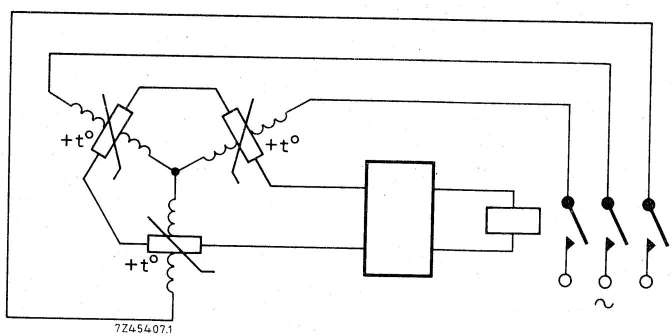
Delaying action relays

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



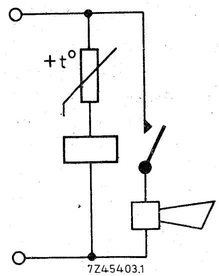
Temperature protection of electric motors

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



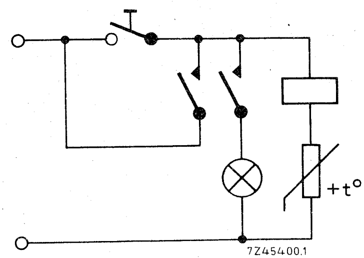
Alarm installation

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



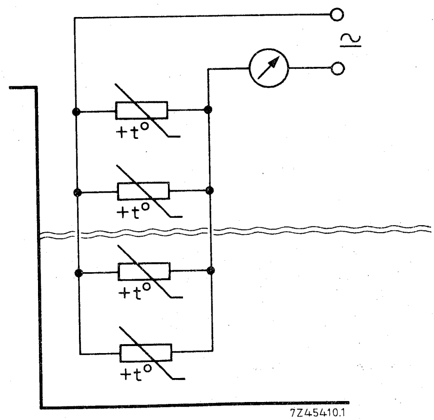
Time delay circuit

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.

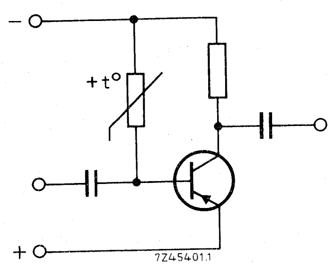


Liquid-level indication

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.

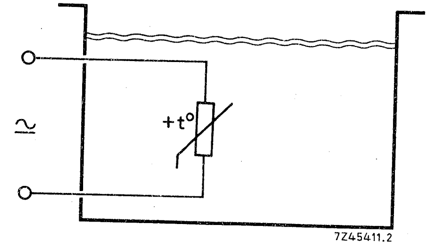


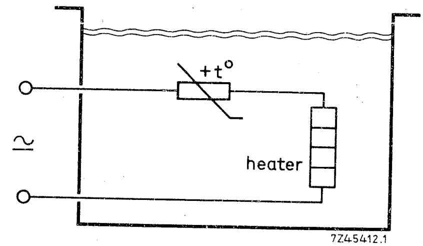
Temperature compensation of transistor circuits



Thermostatically-controlled heating circuits

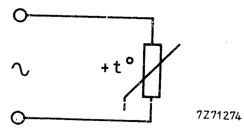
Two principal circuits are possible. In the first circuit the PTC thermistor acts as a control element and as a heater at the same time, while in the second circuit it functions only as a control element.





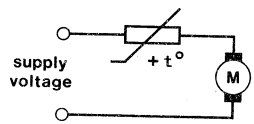
Heating

As e.g. used in hair curling tongs.



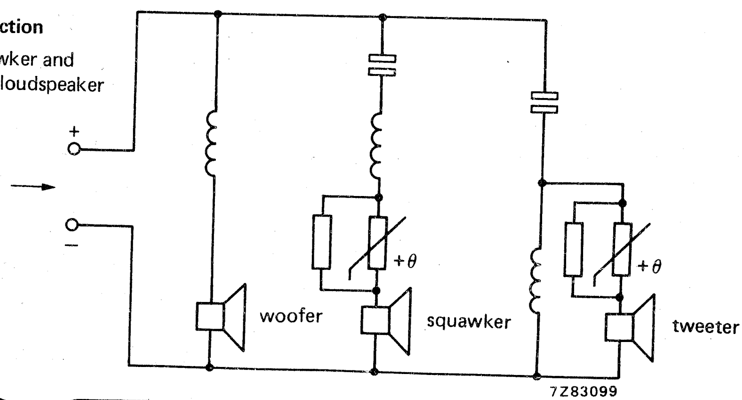
Protection of electric motors against overheating due to blocking

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

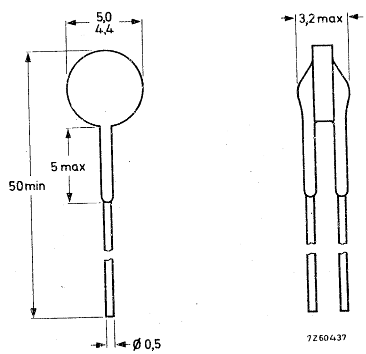


Fig. 1.

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

250 thermistors in a cardboard box.

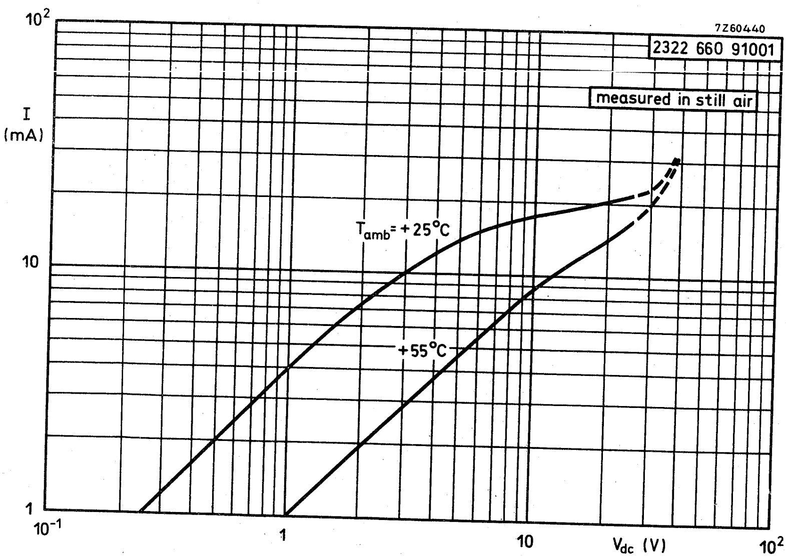


Fig. 2 Typical current/voltage characteristics.

* Measuring voltage not exceeding 1,5 V(d.c.) to avoid internal heating.
** Measurement made with specimen in phosphor bronze clips in still air.

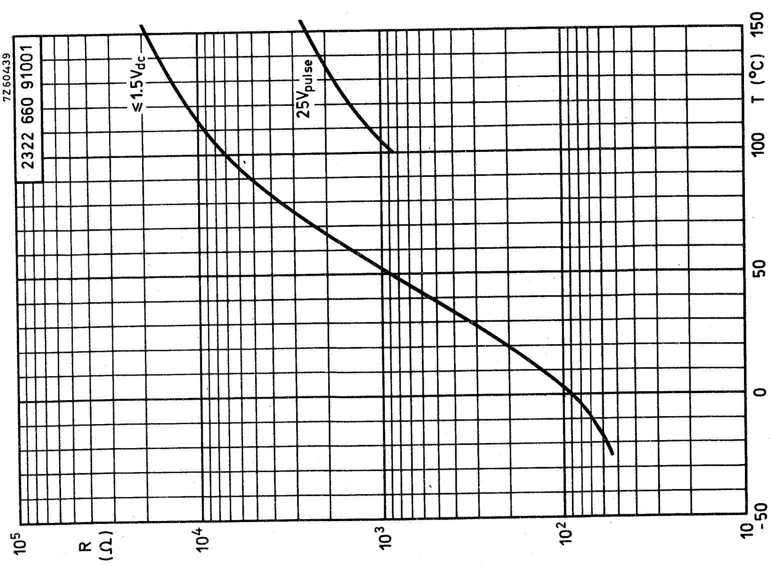


Fig. 3 Typical resistance/temperature characteristics.

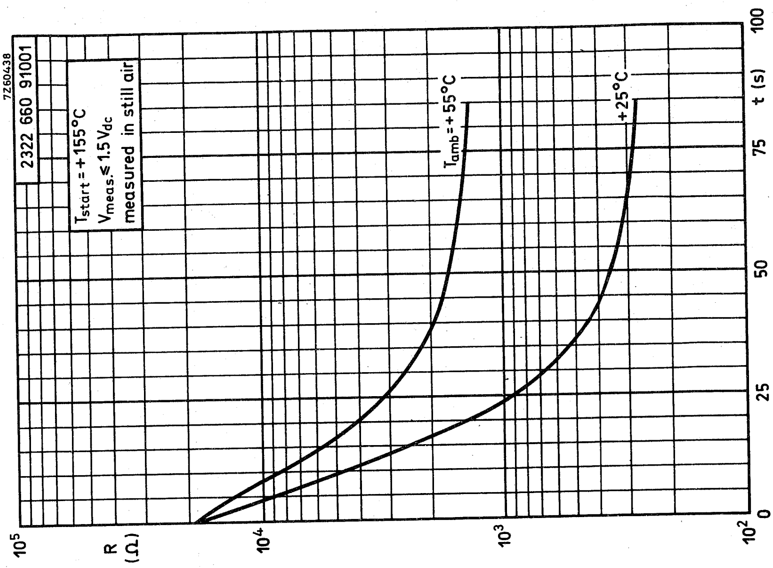


Fig. 4 Typical resistance/time (cooling) characteristics.

PTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance values at +25 °C		50 and 60 Ω ± 30%
Resistance at other temperatures Switch temperature Temperature coefficient		see table
Max. voltage (d.c.)		25 V
Dissipation factor	~	7 mW/K
Operating temperature range at zero power at V_{max}		 −10 to +125 °C * 0 to +55 °C

MECHANICAL DATA

Outlines

catalogue number	colour band
2322 660 91006	red
2322 660 91007	orange
2322 660 91008	yellow
2322 660 91009	green

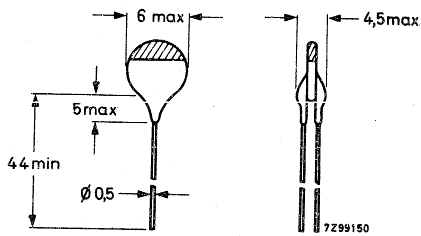


Fig. 1.

APPLICATION

General purpose.

DESCRIPTION

The thermistors have a positive temperature coefficient. They consist of a disc with two tinned copper wires. The thermistor body is blue lacquered but not insulated.

Marking

The thermistors are marked with a colour band at the top of the body according to Fig. 1.

Mass 0,4 g approximately

Mounting In any position by soldering

PACKAGING

250 thermistors in a cardboard box.

* Type 2322 660 91009: −10 to +150 °C.

ELECTRICAL DATA

	catalogue number 2322 660 followed by 91006	91007	91008	91009	
Resistance *					
at 25 °C	60	50	50	50	Ω
at 125 °C	3 to 15	100 to 500	50 to 500		kΩ
at 150 °C				0,1 to 1,2	MΩ
Switch temperature	30	50	80	105	°C
Temperature coefficient	7	16	23	40	%/K
Heat capacity **	0,13	0,13	0,13		J/K
Thermal time constant **	20	18	18		s
Voltage dependence β	0,19	0,17	0,18		
Balance voltage (d.c.)	35	12,5	23		V

Tolerance on R_{25}		± 30%
Max. voltage (d.c.)		25 V
Dissipation factor	~	7 mW/K
Operating temperature range		
at zero power		−10 to +125 °C ***
at V_{max}		0 to +55 °C

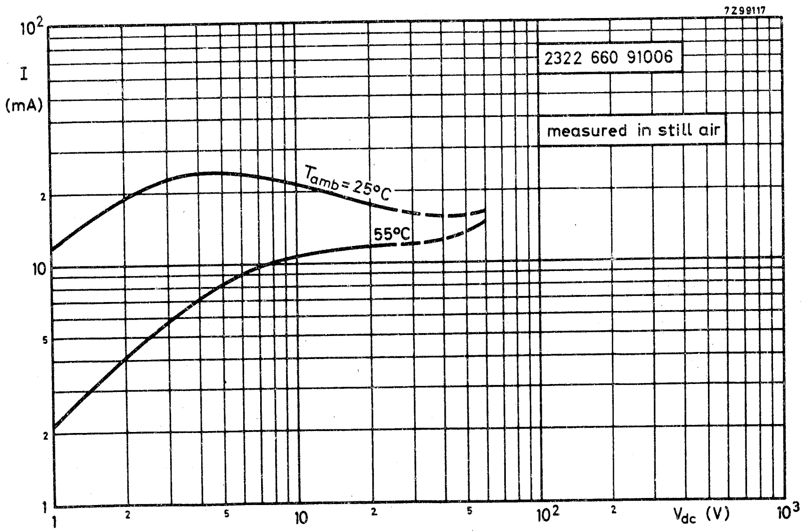


Fig. 2 Typical voltage/current characteristics.

* Measuring voltage not exceeding 1,5 V(d.c.) to avoid internal heating.
** Measurements made with specimen in phosphor bronze clips, in still air.
*** Type 2322 660 91009: −10 to +150 °C.

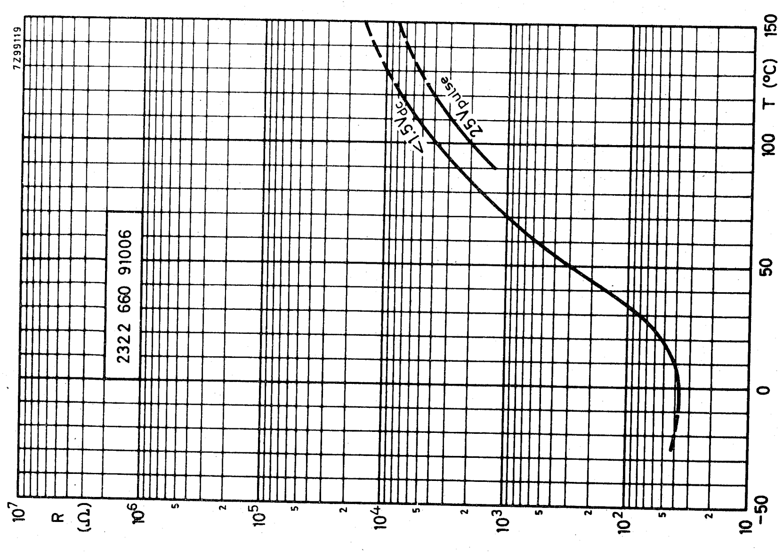


Fig. 3 Typical resistance/temperature characteristics.

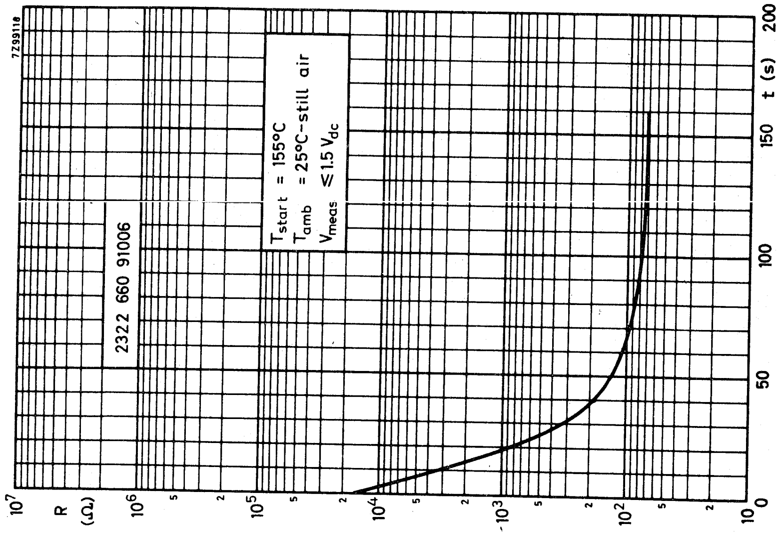


Fig. 4 Typical resistance/time (cooling) characteristic.

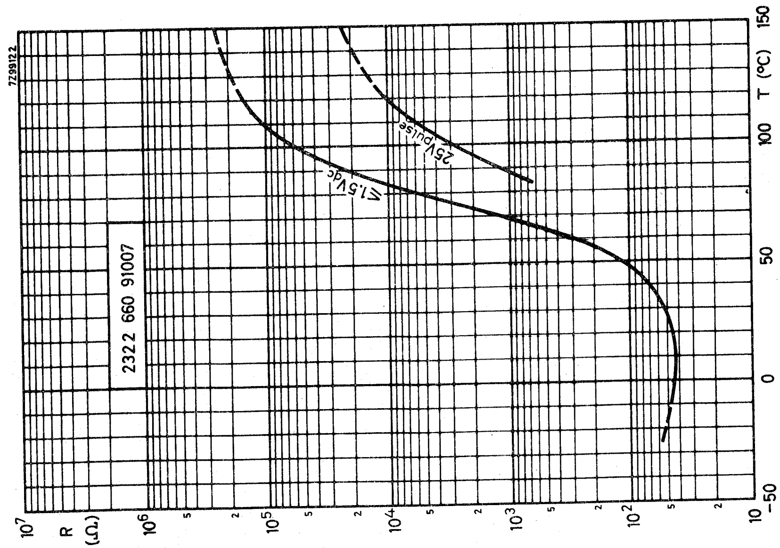


Fig. 5 Typical resistance/temperature characteristics.

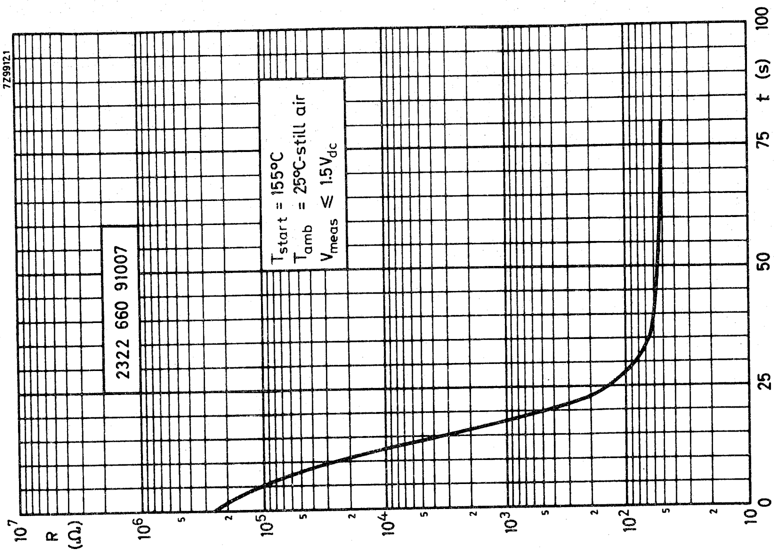


Fig. 6 Typical resistance/time (cooling) characteristic.

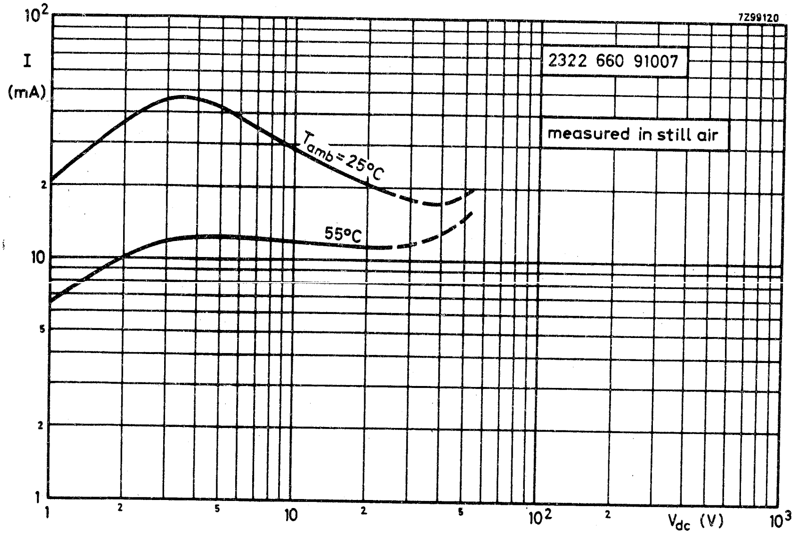


Fig. 7 Typical voltage/current characteristics.

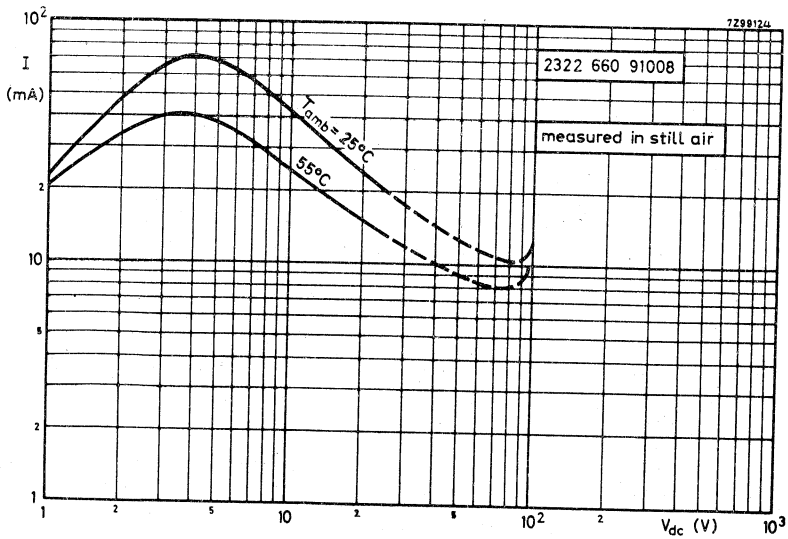


Fig. 8 Typical voltage/current characteristics.

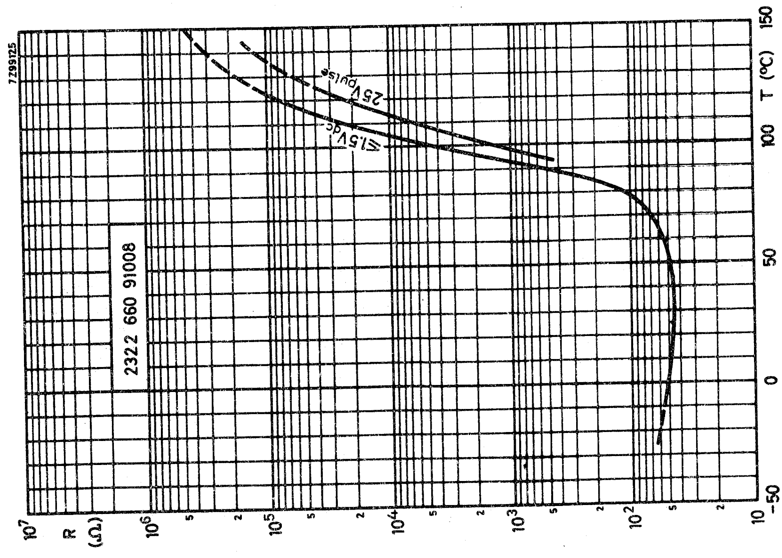


Fig. 9 Typical resistance/temperature characteristics.

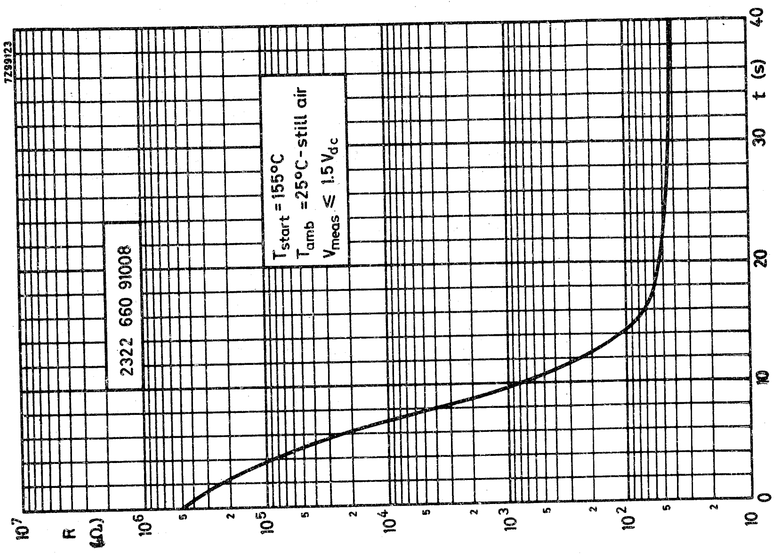


Fig. 10 Typical resistance/time (cooling) characteristic.

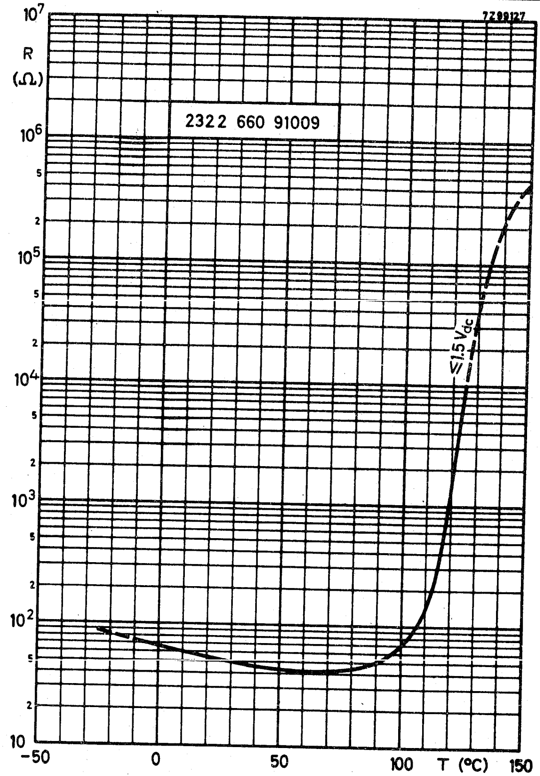


Fig. 11 Typical resistance/temperature characteristic.

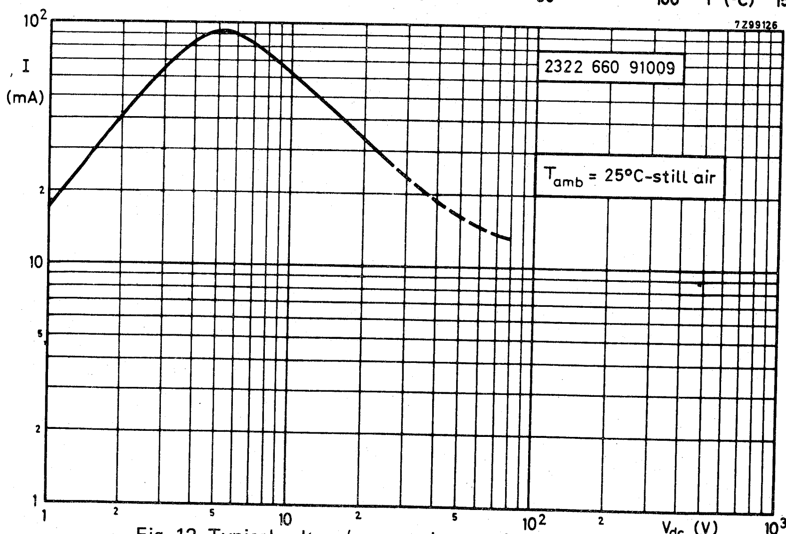


Fig. 12 Typical voltage/current characteristic.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value at +25 °C	750 to 1500 Ω
Resistance value at +175 °C V_{pulse} = 345 V	70 000 Ω
Switch temperature	+115 °C
Temperature coefficient	+26%/K
Maximum voltage (r.m.s.)	245 V
Dissipation factor	7 mW/K
Operating temperature range at zero power at maximum voltage	 −25 to +155 °C 0 to +55 °C

APPLICATION
General purpose.

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

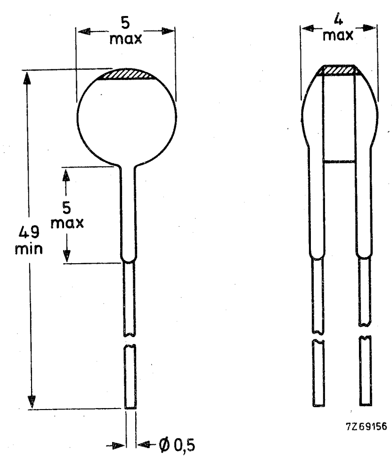


Fig. 1.

PACKAGING
250 thermistors in a cardboard box.

Marking	Brown band on top, see Fig. 1.
Mass	0,4 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	5 N
Bending	2,5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	1000 mm free fall
Inflammability	Uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.
All values in the table without further indication are approximate values.

Resistance at +25 °C	750 to 1500 Ω
Resistance at +115 °C	max. 4000 Ω
Resistance at +175 °C and V_{pulse} = 345 V	min. 70 000 Ω
Switch temperature	+115 °C
Temperature coefficient	+28%/K
Dissipation factor	7 mW/K
Heat capacity	0,125 J/K
of ceramic only	0,08 J/K
Thermal time constant	17,5 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +55 °C
Voltage dependence at +155 °C	0,35
Balance voltage d.c.	90 V
Maximum voltage (r.m.s.)	245 V

* Measurement made without internal heating occurring.

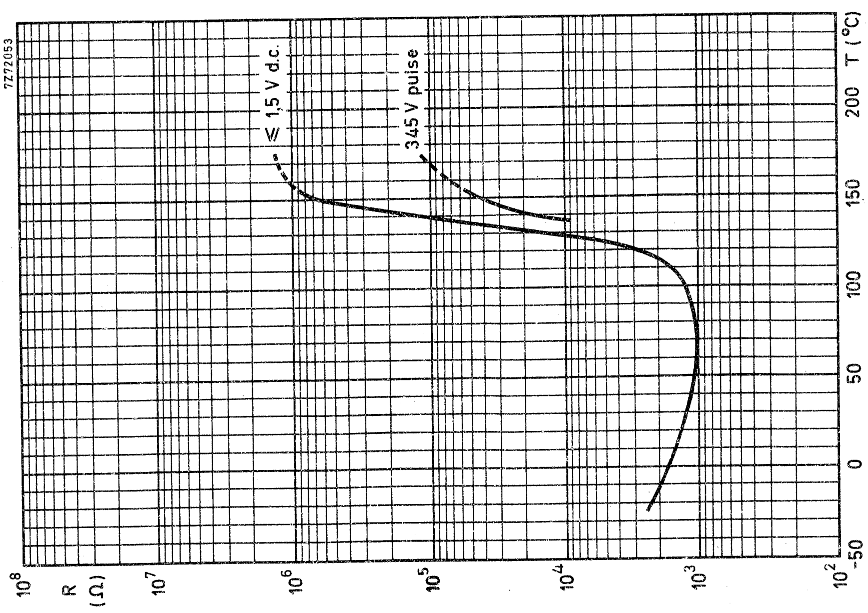


Fig. 2 Typical resistance/temperature characteristics.

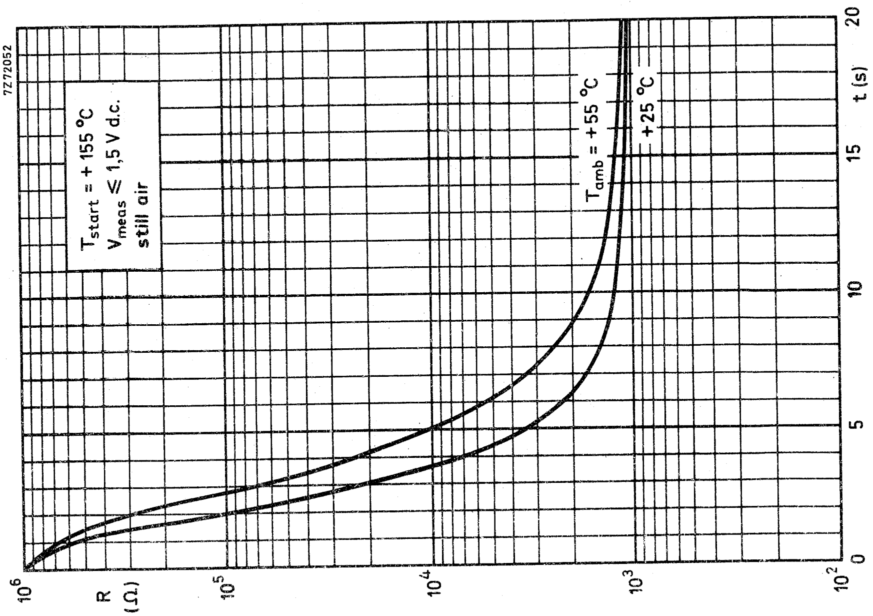


Fig. 3 Typical resistance/time (cooling) characteristics.

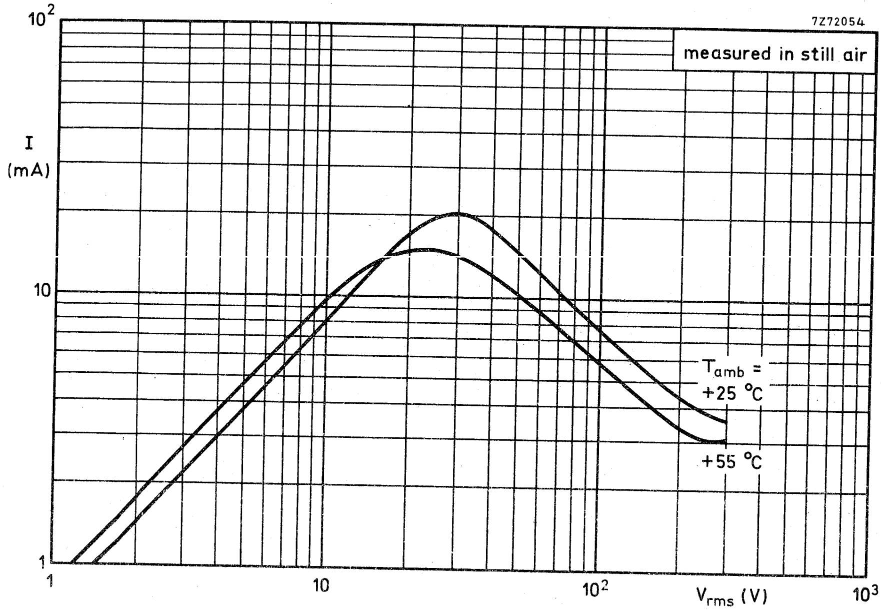


Fig. 4 Typical voltage/current characteristics.

PTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance value at +25 °C	30 to 50 Ω
Operating temperature range	
at zero power	−10 to +125 °C
at V_{max}	0 to +55 °C

APPLICATION

General purpose.

DESCRIPTION

The thermistors have a positive temperature coefficient. They consist of a disc with two tinned copper wires. The thermistor body is blue lacquered but not insulated.

MECHANICAL DATA

Outlines

Table 1

catalogue number	colour band	H_{max}
2322 661 91002	yellow	6
2322 661 91003	green	6
2322 661 91004	orange	6
2322 661 91005	red	5

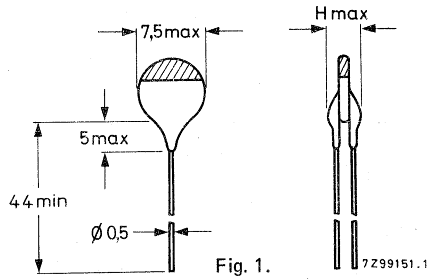


Fig. 1.

Marking

The thermistors are marked with a colour band at the top of the body according to Fig. 1.

Mass 1 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength 10 N
Bending 5 N

Soldering

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

PACKAGING

250 thermistors in a cardboard box.

ELECTRICAL DATA

Table 2, typical values except R and V_{max}

	catalogue number 2322 661 followed by 91002	91003	91004	91005	
Resistance					
at 25 °C *	50	40	30	50	Ω
at 40 °C **			< 90		Ω
at 60 °C **	< 100				Ω
at 95 °C **		< 80			Ω
at 100 °C **	> 1		> 10	3 to 20	kΩ
at 130 °C **		> 10			kΩ
Dissipation factor ***	8,5	8,5	8,5	6	mW/K
Maximum voltage (d.c.)	50	50	50	40	V
Switch temperature	80	110	45	25	°C
Temperature coefficient	18	75	16	9	%/K
Heat capacity ***	0,425	0,425	0,425	0,240	J/K
Thermal time constant ***	50	50	50	40	s
Voltage dependence β	0,48	0,28	0,25	0,35	
Balance voltage (d.c.)	110	25	65	25	V

Tolerance on R_{25} ± 15 Ω

Operating temperature range
- at zero power −10 to +125 °C
- at V_{max} 0 to +55 °C

* Measuring voltage not exceeding 1,5 V (d.c.) to avoid internal heating.
** Measured without internal heating.
*** Measured with phosphor-bronze clips, in still air.

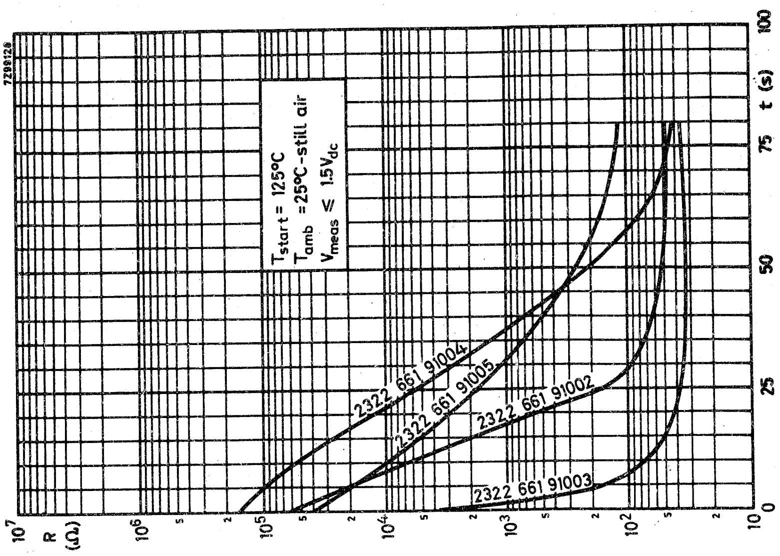


Fig. 3 Typical resistance/time (cooling) characteristics.

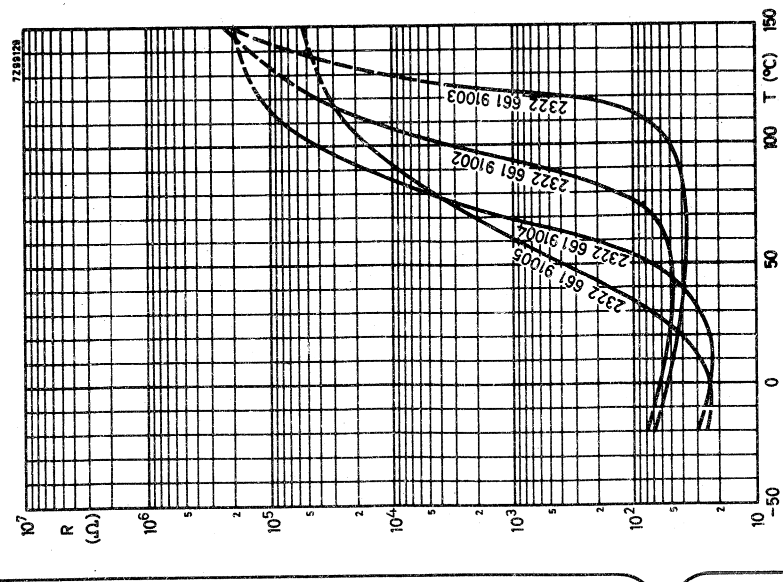


Fig. 2 Typical resistance/temperature characteristics.

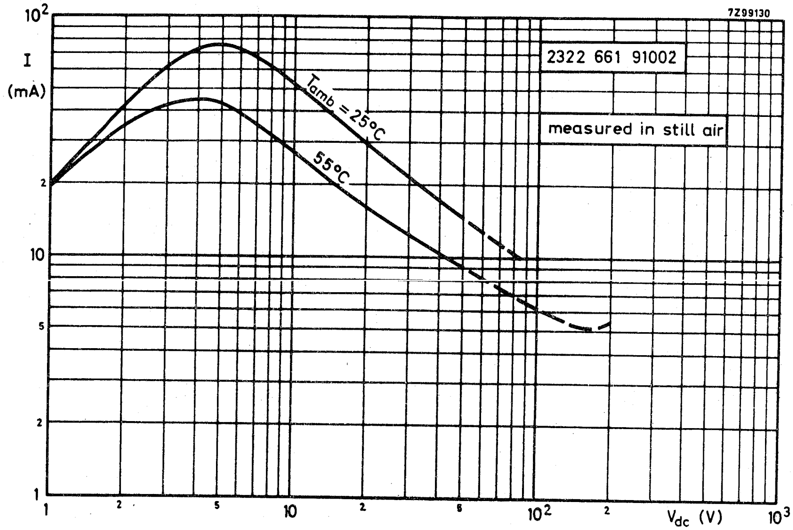


Fig. 4 Voltage/current characteristics.

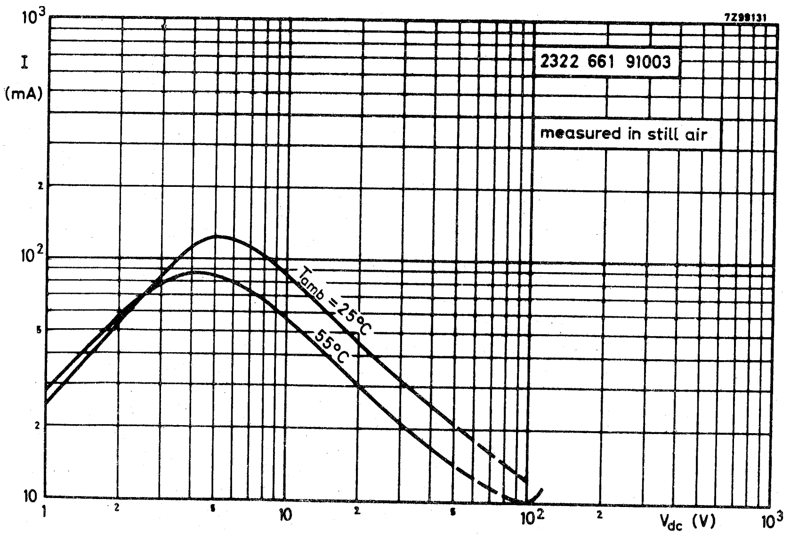


Fig. 5 Voltage/current characteristics.

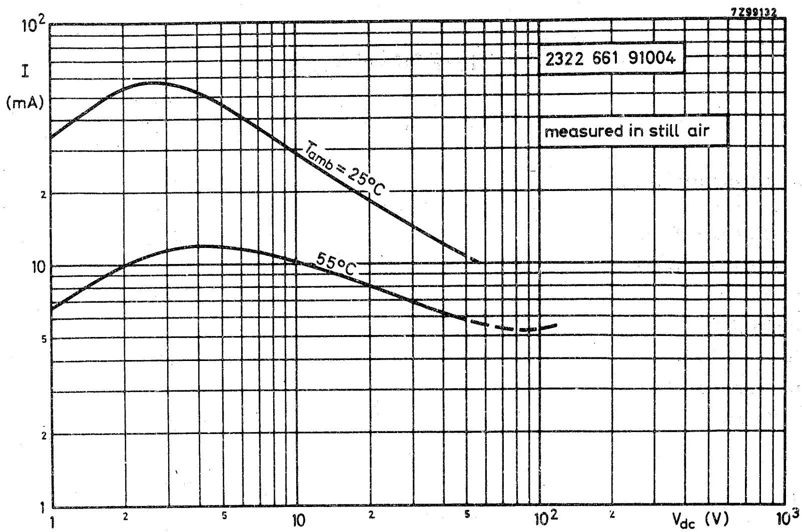


Fig. 6 Voltage/current characteristics.

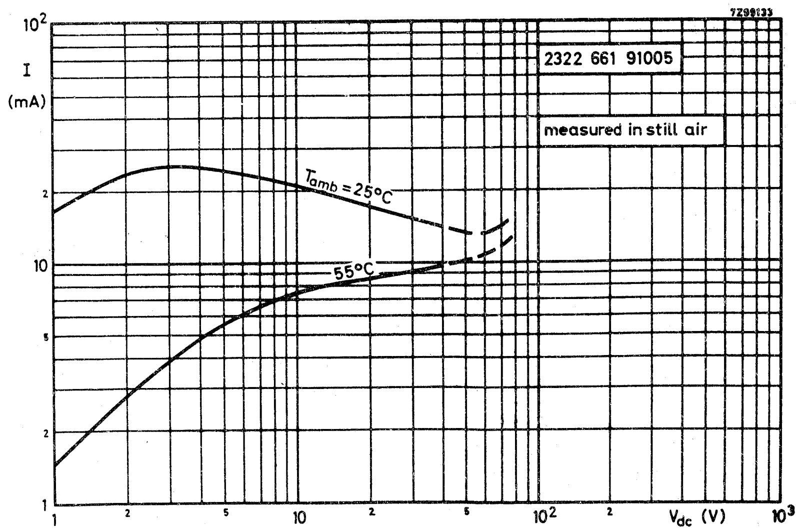


Fig. 7 Voltage/current characteristics.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value at +25 °C		36 to 50 Ω
Resistance value at +165 °C V_{pulse} = 180 V		> 20 kΩ
Switch temperature	~	+115 °C
Temperature coefficient	~	35%/K
Maximum voltage (d.c.)		180 V
Dissipation factor	~	13 mW/K
Operating temperature range at zero power at maximum voltage (d.c.)		 0 to +155 °C 0 to +55 °C

APPLICATION

Protection of telegraphy relay contacts.

DESCRIPTION

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

MECHANICAL DATA

Outlines

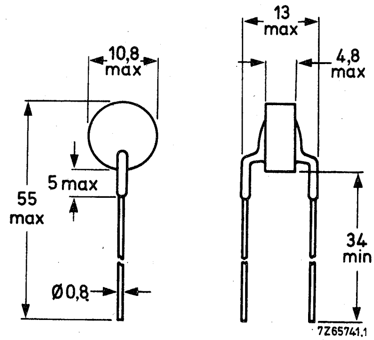


Fig. 1.

Mass 0,5 g approximately

Mounting In any position by soldering

PACKAGING

50 thermistors in a cardboard box.

ELECTRICAL DATA

Resistance		
at +25 °C (T_{ref})*		36 to 50 Ω
at +115 °C*		< 120 Ω
at +165 °C, V_{pulse} = 180 V**		> 20 kΩ
Current at +25 °C, V_{dc} = 180 V continuously ***		< 10 mA
Switch temperature	~	+115 °C
Temperature coefficient	~	35%/K
Dissipation factor ***	~	13 mW/K
Heat capacity ***		1 J/K
Thermal time constant ***	~	80 s
Operating temperature range		
at zero power		0 to +155 °C
at V_{max}		0 to +55 °C
Voltage dependence β at +150 °C	~	0,3
Balance voltage (d.c.)	~	105 V
Maximum voltage (d.c.) at +55 °C		180 V

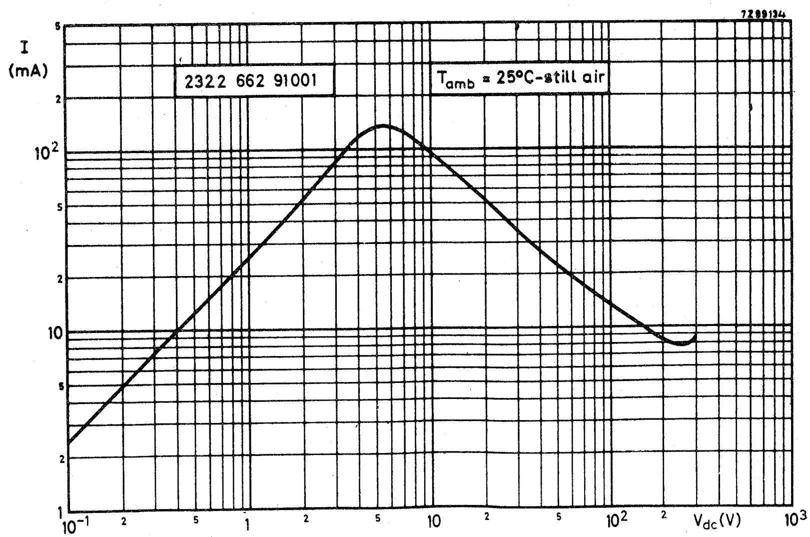


Fig. 2 Typical voltage/current characteristic.

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

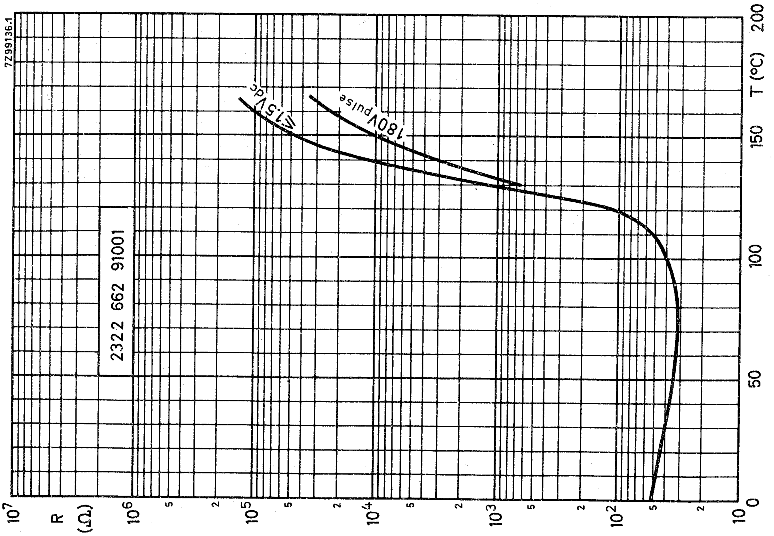


Fig. 3 Typical resistance/temperature characteristics.

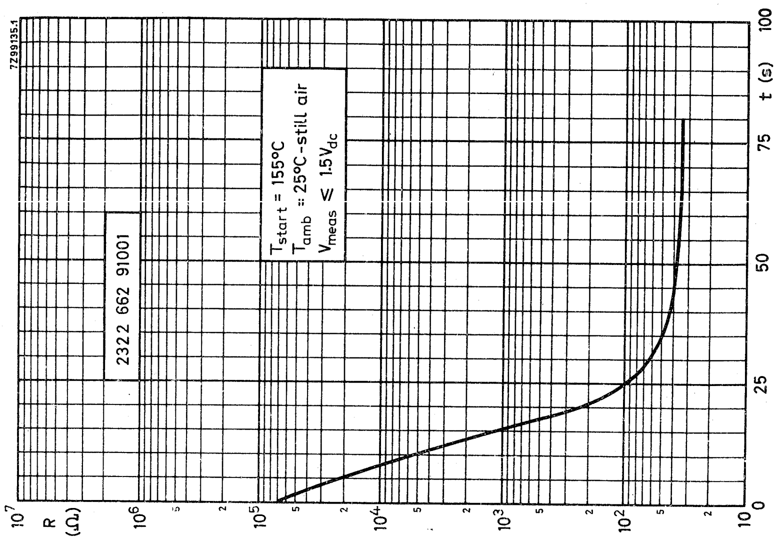


Fig. 4 Typical resistance/time (cooling) characteristic.

PTC THERMISTOR

disc

QUICK REFERENCE DATA

Resistance value at +25 °C	max. 1,1 Ω
Resistance value at +55 °C	max. 1 Ω
Switch temperature	+100 °C
Temperature coefficient	+6%/K
Maximum r.m.s. voltage	18 V
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +55 °C

APPLICATION

Overload protection of loudspeakers.

DESCRIPTION

The thermistor has a positive temperature coefficient. It consists of a disc with two tinned brass wires.

MECHANICAL DATA

Outlines

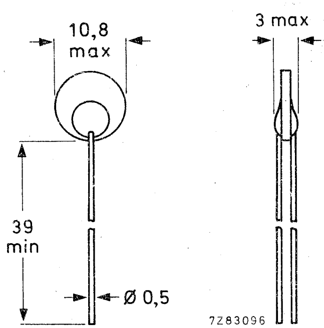


Fig. 1.

Marking None

Mass 0,55 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

Impact 0,2 m free fall

Inflammability Uninflammable

ELECTRICAL DATA

All values in the table without further indication are approximate values

Resistance at +25 °C	max. 1,1 Ω
Resistance at +115 °C	max. 1 Ω
Switch temperature	+100 °C
Switching current at T_{amb} = +25 °C	max. 710 mA
Max. current at which no switching occurs at T_{amb} = +25 °C	570 mA
Temperature coefficient	+6%/K
Maximum r.m.s. voltage	18 V
Response time at I = 1,3 A and T_{amb} = +25 °C	max. 20 s
Steady state current at 18 V r.m.s. and T_{amb} = +25 °C	max. 95 mA
Operating temperature range	
at zero power	–25 to +155 °C
at maximum voltage	0 to +55 °C

PACKAGING

5000 thermistors in a cardboard box.

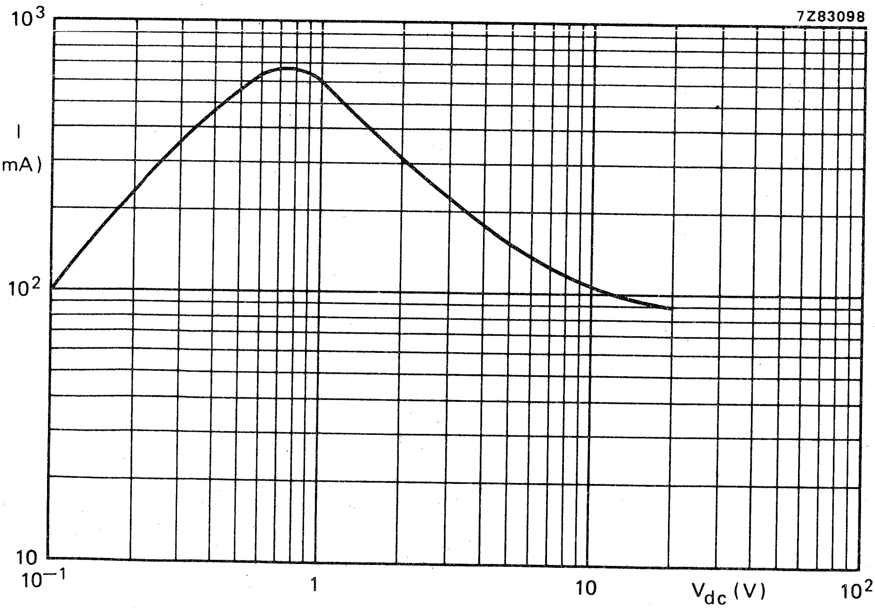


Fig. 2 Typical current/voltage characteristic.

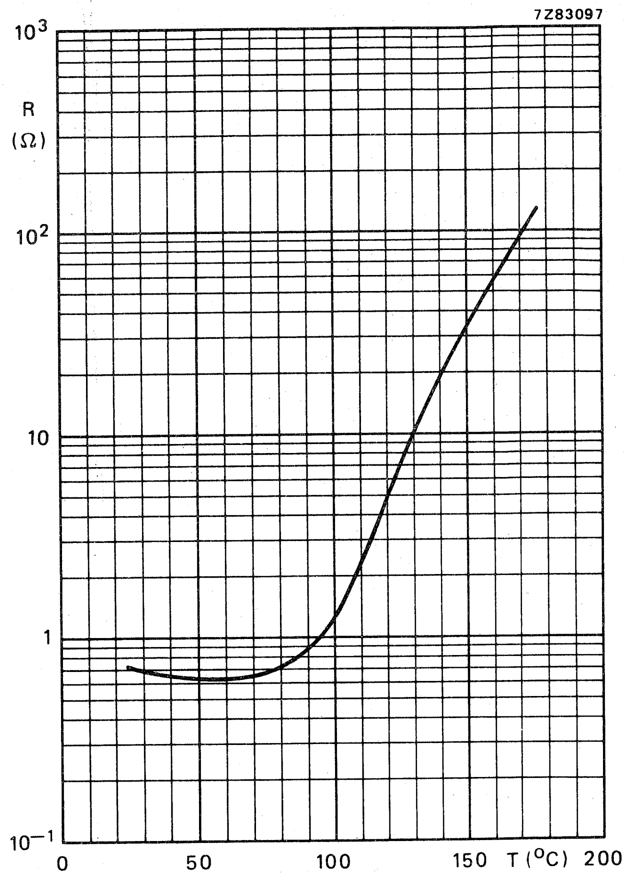


Fig. 3 Typical resistance/temperature characteristic.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value at +25 °C	70 to 100 Ω
Max. current at 600 V r.m.s. and +25 °C	5 mA
Switch temperature	+120 °C
Temperature coefficient	+35%/K
Maximum r.m.s. voltage	460 V
Dissipation factor	11,5 mW/K
Operating temperature range	
at zero power	–25 to +175 °C
at maximum voltage	0 to +85 °C

APPLICATION

Suitable in all kinds of applications, e.g. fluorescent lamp starter.

DESCRIPTION

This thermistor has a positive temperature coefficient. It is a leadless disc which is neither lacquered nor insulated.

MECHANICAL DATA

Outlines

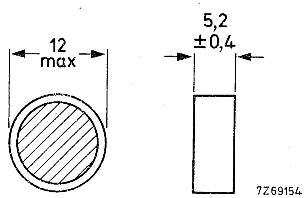


Fig.1.

Marking	None
Mass	2,7 g approximately
Mounting	In any position by clamping
Impact	100 mm free fall
Inflammability	Uninflammable

PACKAGING

Plastic blister pack containing 60 items.

ELECTRICAL DATA

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

Resistance at +25 °C	70 to 100 Ω
Resistance at +100 °C	max. 200 Ω
Max. current at 600 V r.m.s. and +25 °C (measurement made without internal heating)	5 mA
Switch temperature	+120 °C
Temperature coefficient	+35%/K
Dissipation factor	11,5 mW/K
Heat capacity	1,3 J/K
Thermal time constant	115 s
Operating temperature range	
at zero power	–25 to +175 °C
at maximum voltage	0 to +85 °C
Voltage dependence at +175 °C	0,22
Balance voltage	230 V
Maximum r.m.s. voltage, with series resistor of 300 Ω	460 V

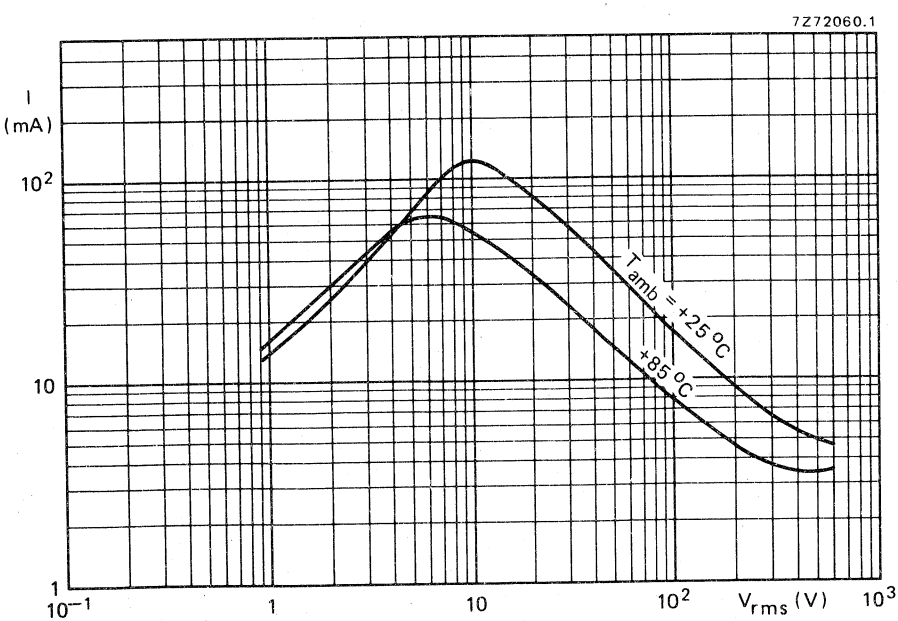


Fig. 2 Typical voltage/current characteristics.

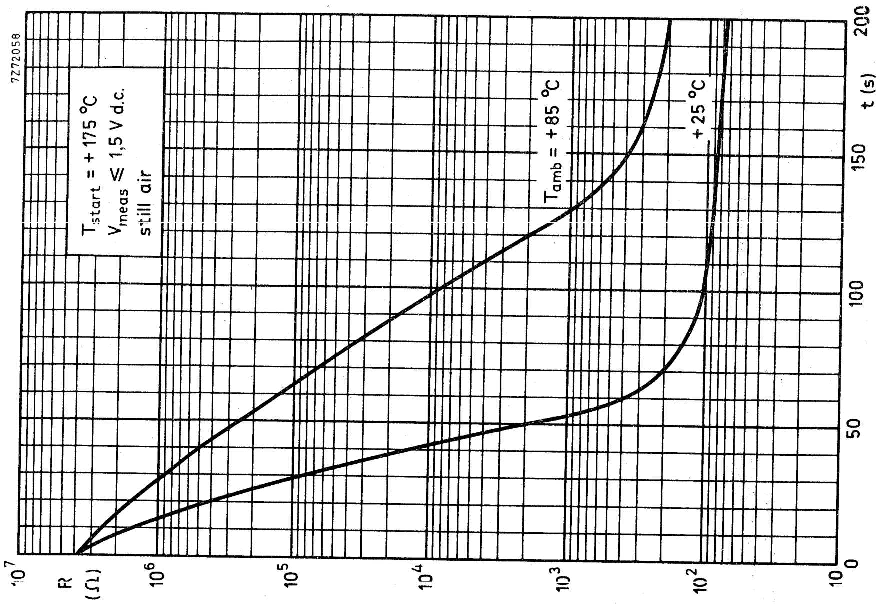


Fig. 3 Typical resistance/time (cooling) characteristics.

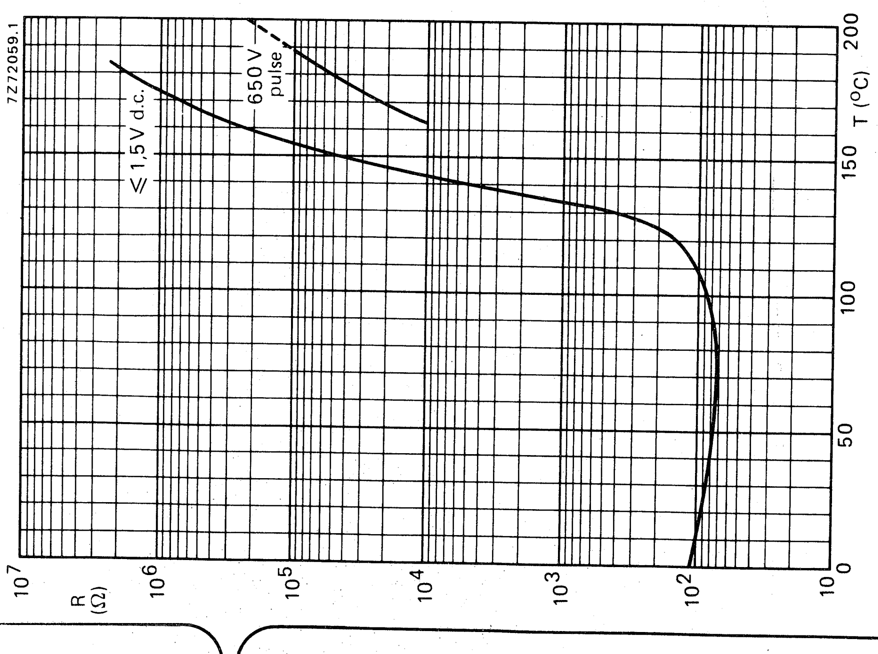


Fig. 2 Typical resistance/temperature characteristics.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value		
at +25 °C		45 to 60 Ω
at +150 °C		> 45 kΩ
V_{pulse} = 340 V		
Switch temperature	~	+75 °C
Temperature coefficient	~	+20%/K
Max. r.m.s. voltage at $T_{amb} \leq 60$ °C		265 V
Dissipation factor	~	20 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 is a disc with two tinned copper wires. The thermistor body is blue lacquered, but not insulated.

MECHANICAL DATA

Outlines

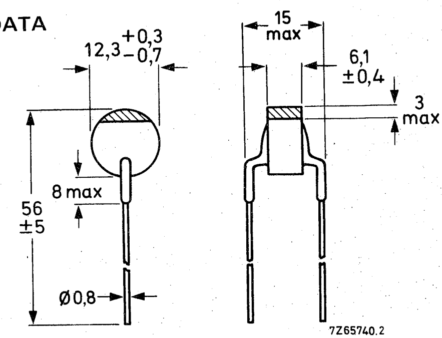


Fig. 1.

Marking Green colour band on top of the body.

Mass 4,2 g approximately.

Mounting In any position by soldering. Soldering should be done at least 15 mm from the thermistor body.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Resistance		
at +25 °C *		45 to 60 Ω
at +75 °C *		< 160 Ω
at +150 °C, V_{pulse} = 340 V **		> 45 kΩ
Switch temperature	~	+75 °C
Temperature coefficient	~	+20%/K
Dissipation factor ***	~	20 mW/K
Heat capacity ***	~	2,2 J/K
Thermal time constant ***	~	110 s
Operating temperature range		
at zero power		−25 to +155 °C
at V_{max}		0 to +60 °C
Voltage dependence β at +155 °C	~	0,29
Balance voltage (d.c.)	~	200 V
Maximum r.m.s. voltage, with series resistor of 33 Ω		265 V

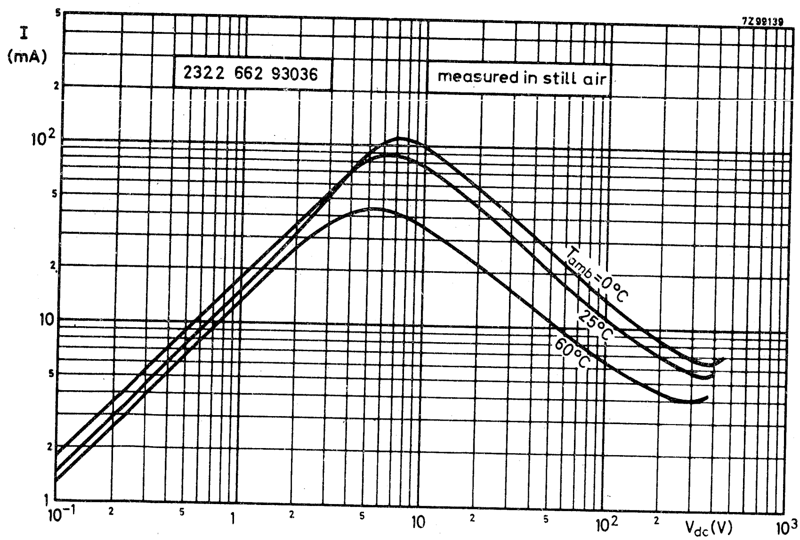


Fig. 2 Typical voltage/current characteristics.

* 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.

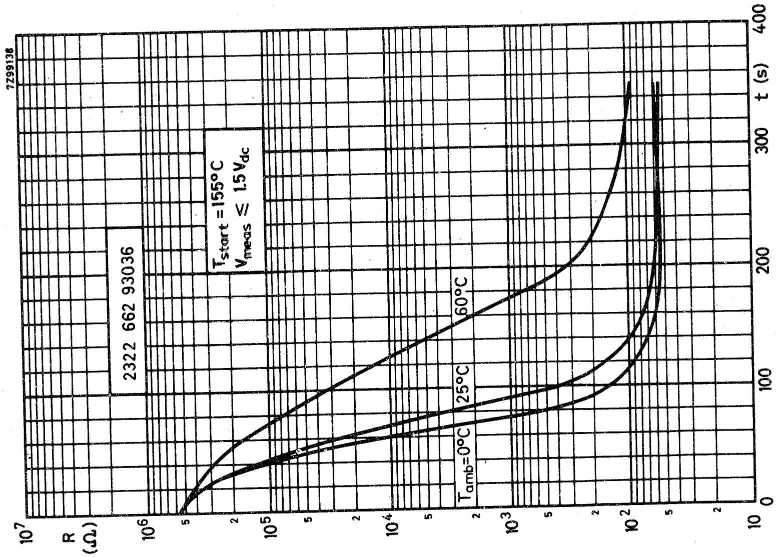


Fig. 4 Typical resistance/time (cooling) characteristics.

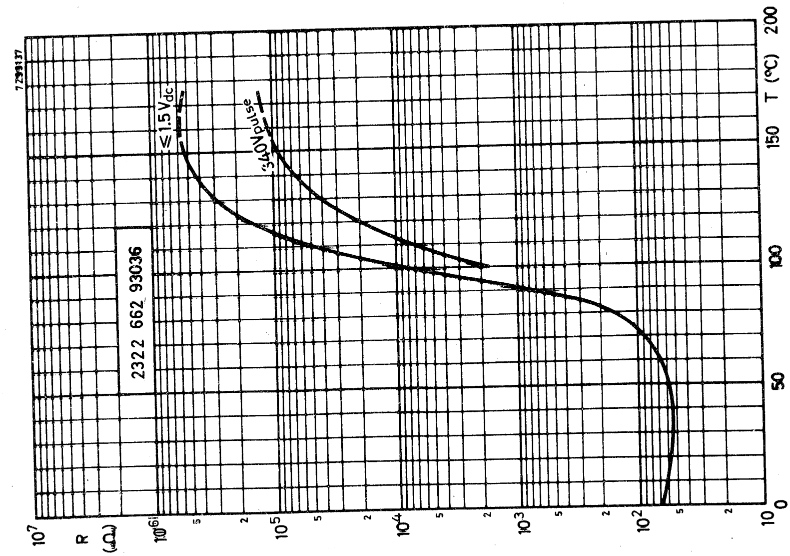


Fig. 3 Typical resistance/temperature characteristics (no internal heating).

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
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

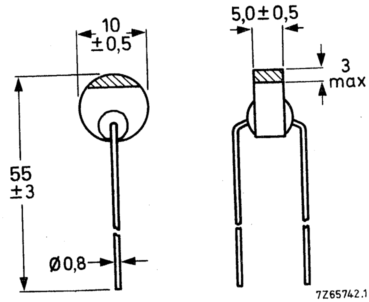


Fig. 1.

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 *	$< 2 \times R_{25}$
at +85 °C *	$> 2 \times R_{25}$
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.

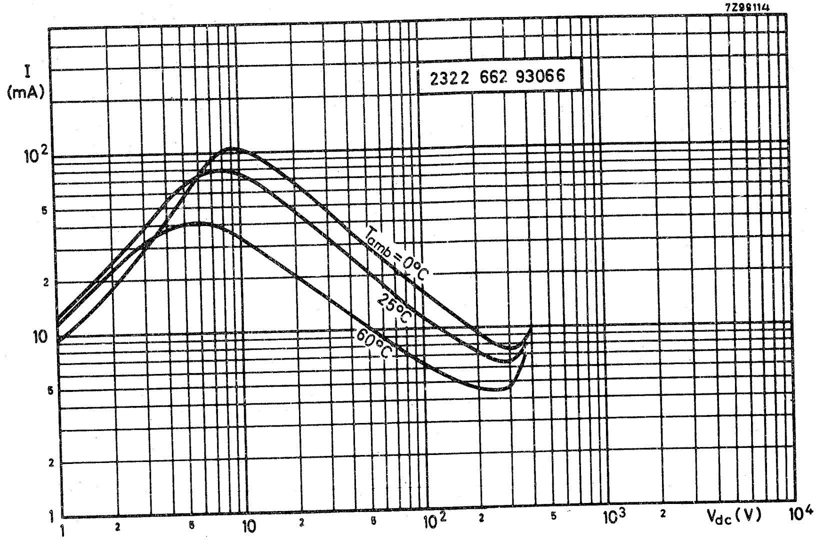


Fig. 3 Typical voltage/current characteristics.

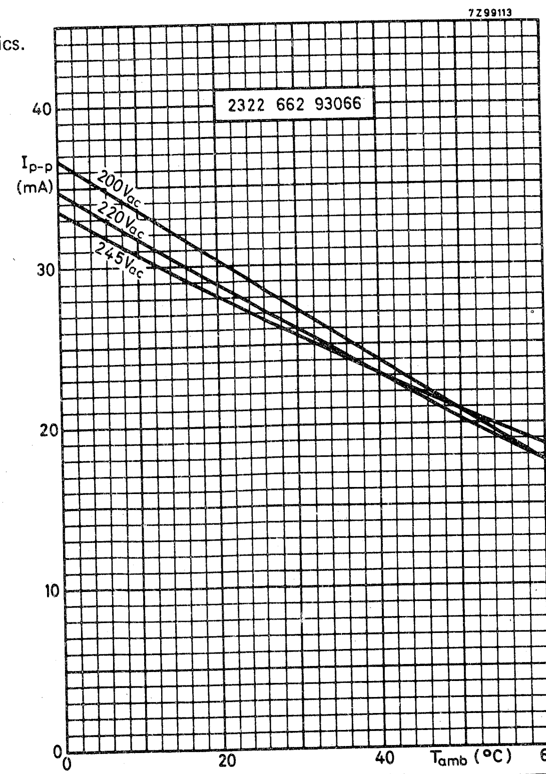


Fig. 4 Typical characteristics of peak to peak current against the ambient temperature at different voltages.

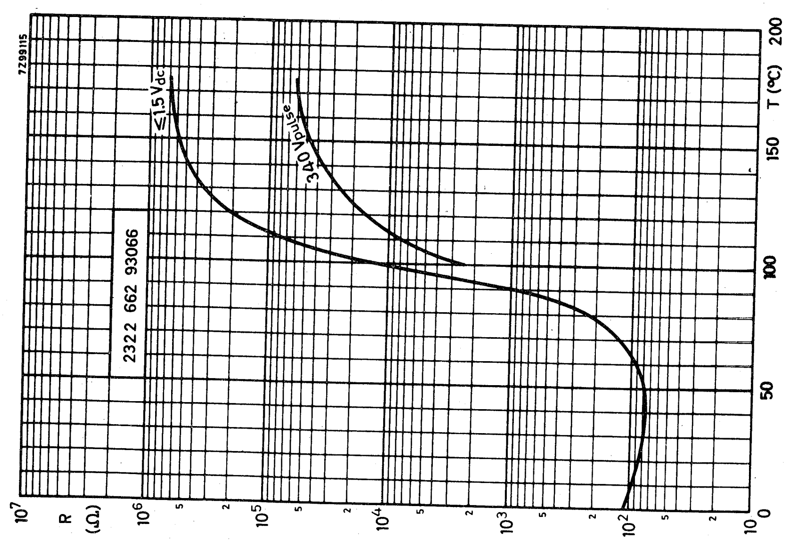


Fig. 5 Typical resistance/temperature characteristics.

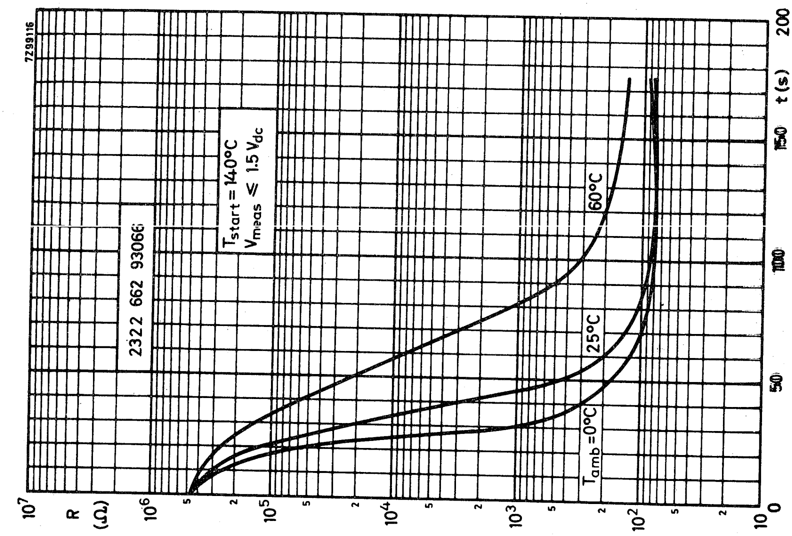


Fig. 6 Typical resistance/time (cooling) characteristics.

DUAL PTC THERMISTORS

QUICK REFERENCE DATA

	2322 662 98001	2322 662 98003
R.M.S. current through the coil measured at	200 V	220 V
min. inrush peak current	5 A	5 A
max. idle peak current		
after 5 s	70 mA	70 mA
after 30 s	5 mA	5 mA
after 3 min	2 mA	2 mA
Maximum r.m.s. voltage	245 V	265 V
Switch temperature	75 °C	
Operating temperature range		
at zero power	–25 to +155 °C	
at maximum voltage	0 to +60 °C	

APPLICATION

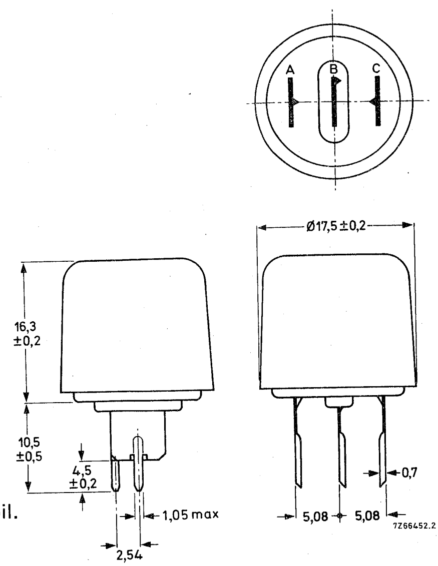
In degaussing circuits of colour television sets.

DESCRIPTION

The thermistor consists of two disc PTC thermistors clamped between spring contacts. This assembly ensures a good thermal contact between both discs, which is essential for function of this device. The thermistor is enclosed in a plastic housing. The three connecting pins are arranged to fit a printed-wiring board with an 0,1 inch grid.

MECHANICAL DATA

Outlines



A is to be connected to the mains;
C is to be connected to the degaussing coil.

Fig. 1.

Marking	The catalogue number is moulded in the top of the cap
Mass	7,3 g approximately
Mounting	In any position by soldering
Robustness of terminations	
Tensile strength	20 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	
Free fall	1000 mm

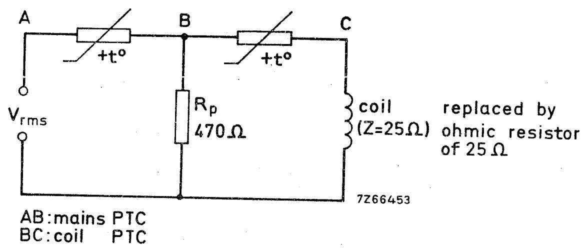


Fig. 2 Measuring circuit. R_p must be able to withstand a peak power of 25 W for 300 ms.

ELECTRICAL DATA

		2322 662 98001		2322 662 98003
R.M.S. current through the coil				
measured in circuit of Fig. 2 at		200		220 V
min. inrush current		5		5 A
max. idle peak current				
after 5 s		70		70 mA
after 30 s		5		5 mA
after 3 min		2		2 mA
Resistance at +25 °C:				
of mains PTC *	~	25	~	30 Ω
of coil PTC *	~	8	~	8 Ω
at T_{amb} = +175 °C and 345 V pulsed: of mains PTC**	⩾	32	⩾	35 kΩ
at T_{amb} = +155 °C: of coil PTC	⩾	20	⩾	20 kΩ
Switch temperature of mains and coil PTC		75		75 °C
Temperature coefficient				
of mains PTC	~	23	~	25 %/K
of coil PTC	~	25	~	25 %/K
Balance voltage (d.c.) of mains PTC	~	190	~	160 V
Voltage dependency at +155 °C of mains PTC	~	0,28	~	0,26
Maximum r.m.s. voltage in circuit ***		245		265 V
Dissipation factor ***	~	13,5	~	13,5 mW/K
Thermal time constant ***	~	200	~	200 s
Heat capacity of ceramic				
of mains PTC	~	1,6	~	1,6 J/K
of coil PTC	~	0,47	~	0,43 J/K
of complete assembly ***	~	2,7	~	2,7 J/K
Operating temperature range				
at zero power		−25 to +155		−25 to +155 °C
at maximum voltage		0 to +60		0 to +60 °C

* Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating.
** Measured without self heating.
*** In still air, the thermistor soldered on printed-wiring board.

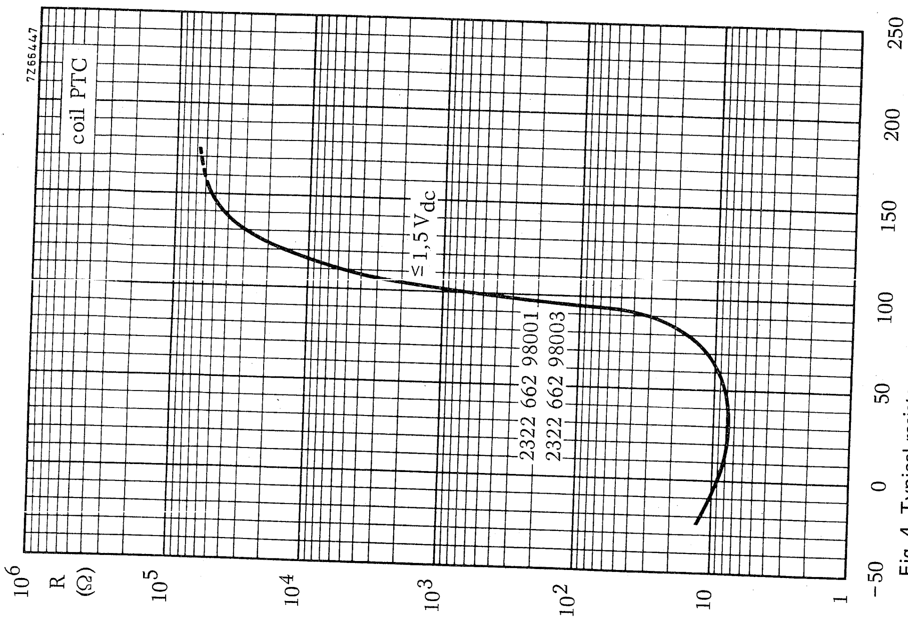


Fig. 4 Typical resistance versus temperature characteristics of the coil PTC thermistor.

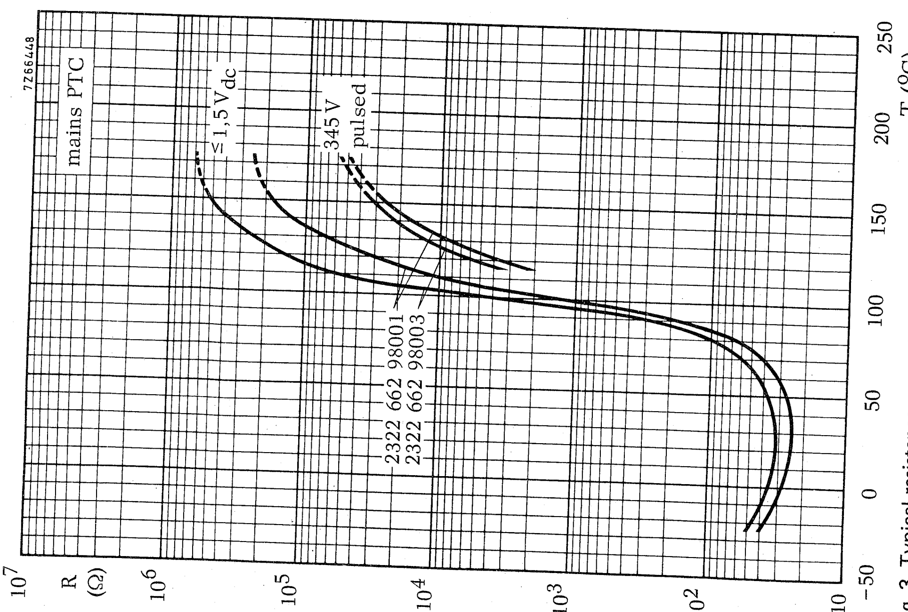


Fig. 3 Typical resistance versus temperature characteristics of the mains PTC thermistor.

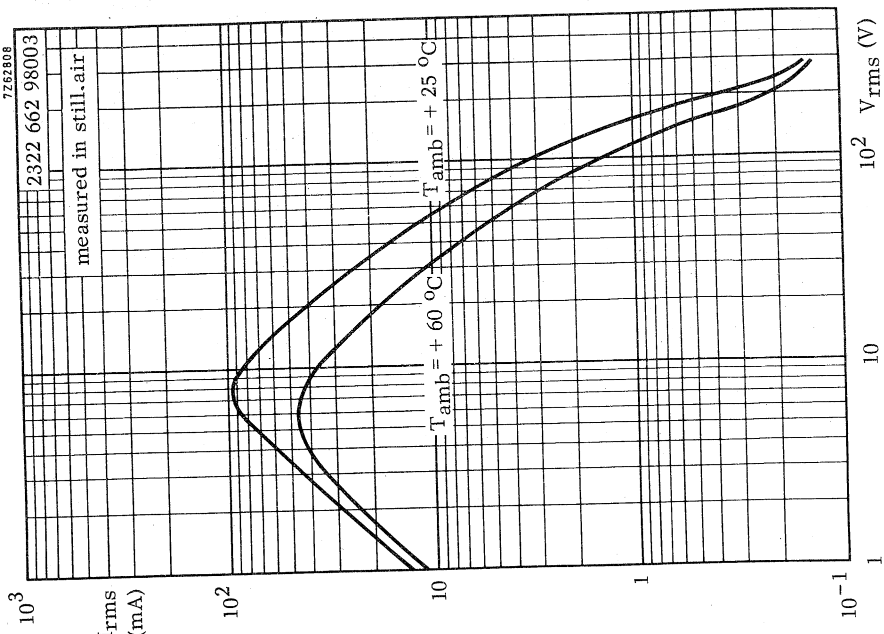


Fig. 6 Typical static current through the coil versus voltage characteristics.

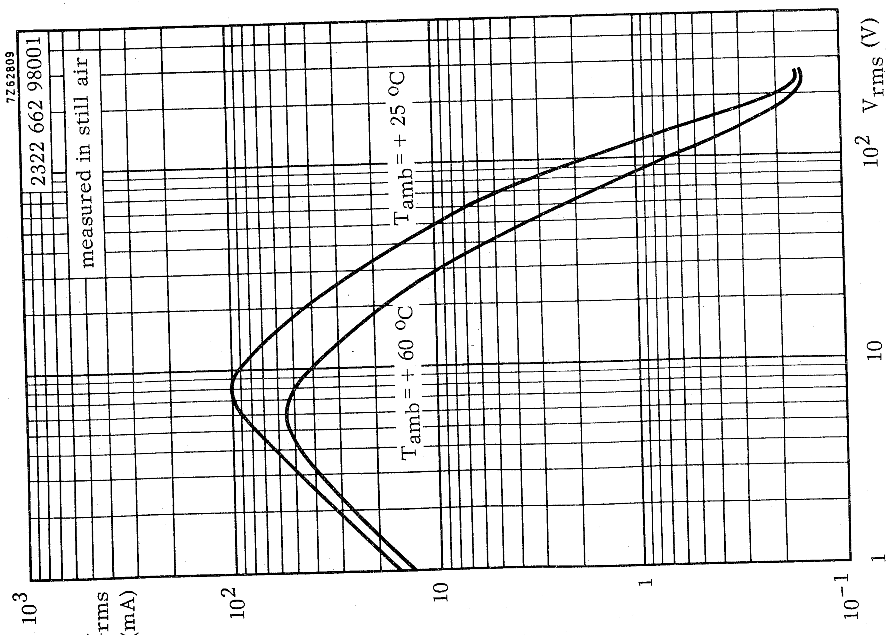


Fig. 5 Typical static current through the coil versus voltage characteristics.

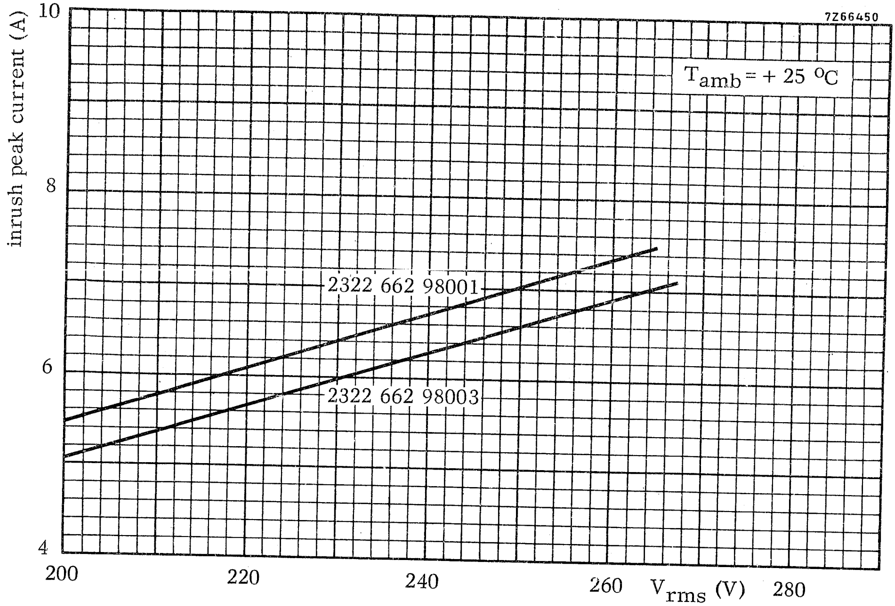


Fig. 7 Typical inrush peak current versus voltage characteristics.

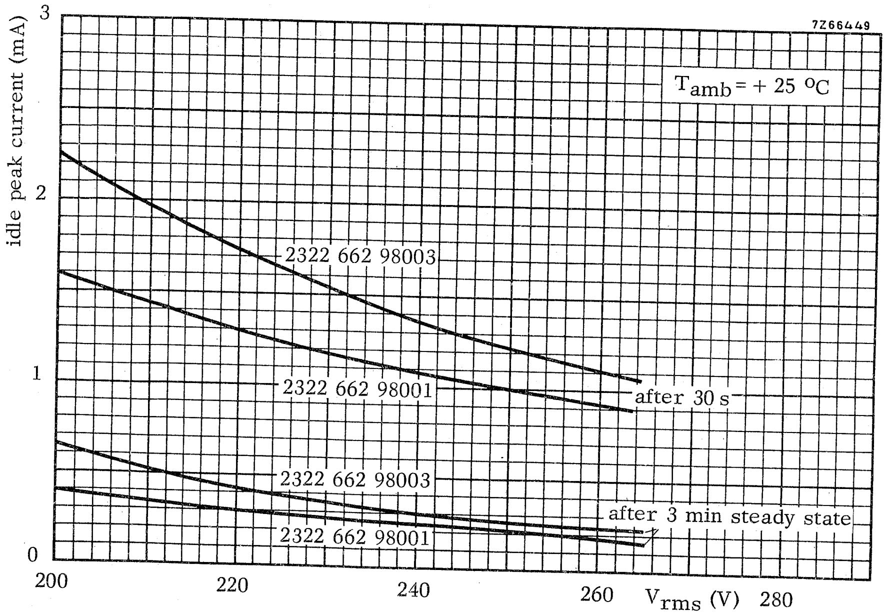


Fig. 8 Typical peak idle current versus voltage characteristics.

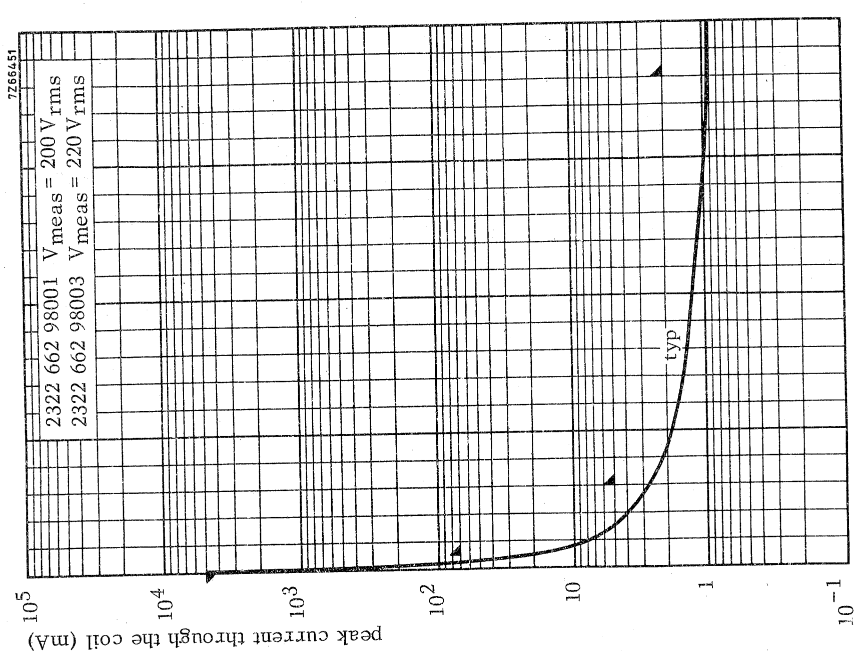


Fig. 10 Typical peak current through the coil versus time characteristic.

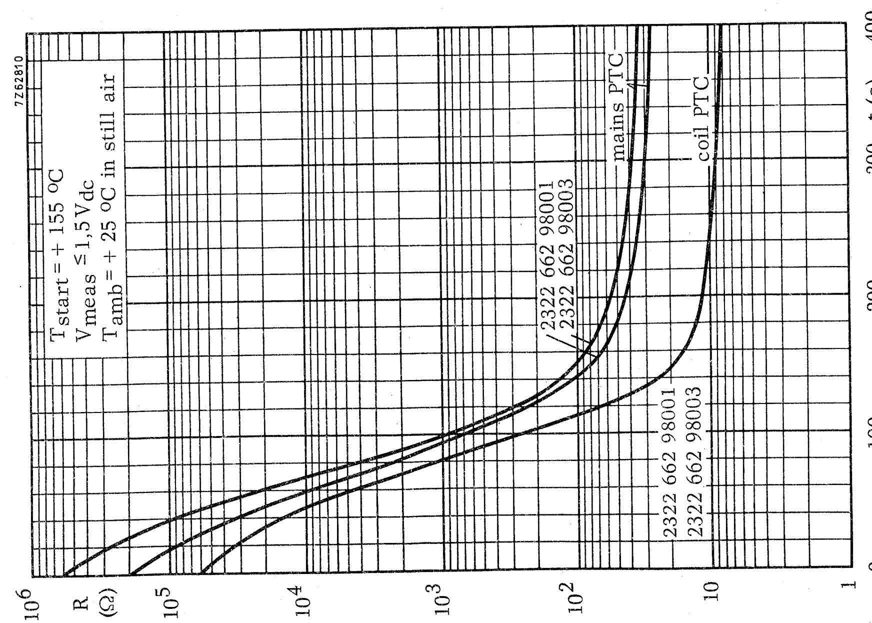


Fig. 9 Typical resistance versus cooling time characteristics of mains PTC thermistor.

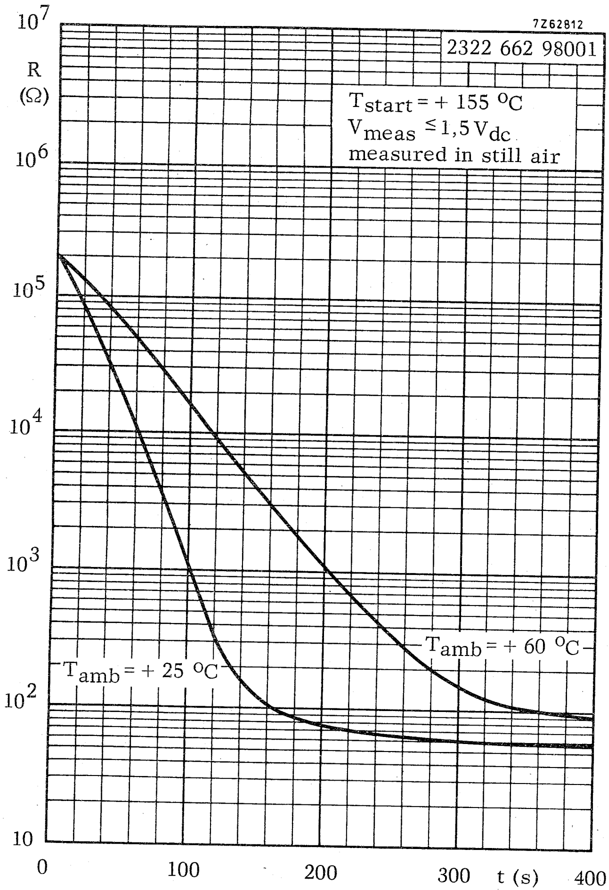


Fig. 11 Typical resistance of circuit versus cooling time characteristics.

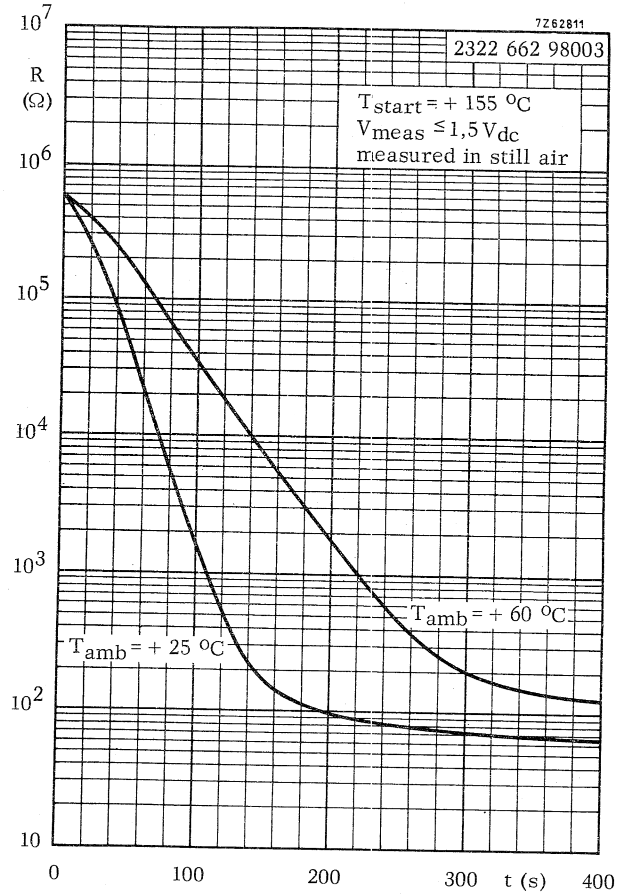


Fig. 12 Typical resistance of circuit versus cooling time characteristics.

DUAL PTC THERMISTOR
parallel-series

QUICK REFERENCE DATA

Current through the coil at 200 V r.m.s.	
min. inrush peak current	5 A
max. peak current	
after 5 s	70 mA
after 30 s	5 mA
after 3 min	2 mA
Maximum r.m.s. voltage	265 V
Operating temperature range	
at zero power	−25 to +125 °C
at maximum voltage	0 to +60 °C

APPLICATION

In degaussing circuits of colour television sets.

DESCRIPTION

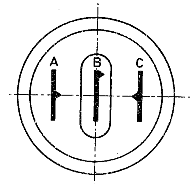
The dual PTC consists of two disc PTC thermistors clamped between spring contacts. This assembly ensures a good thermal contact between both discs, which is essential for the function of this device. The thermistor is enclosed in a white plastic housing. The three connecting pins are arranged to fit a printed-wiring board with an 0,1 inch grid.

The parallel PTC thermistor is connected across the supply, the series PTC thermistor is connected in series with the degaussing coil. The series PTC would not by itself lower the current to 2 mA, but would stabilize the current above this value. By applying further heat to the series PTC, its resistance will increase to the point where the coil current is limited to 2 mA. This extra heat is provided by the parallel PTC.

MECHANICAL DATA

Outlines

A and B are to be connected to the mains;
A and C are to be connected to the degaussing coil (see also Fig. 2).



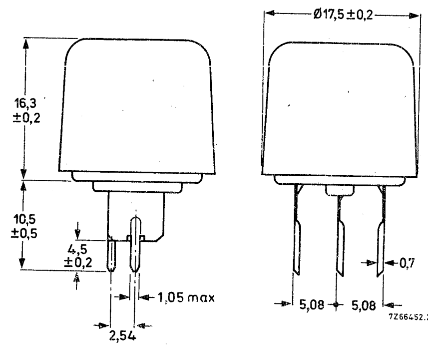


Fig. 1.

Marking	The catalogue number is moulded in the top of the cap.
Mass	7,3 g approximately
Mounting	The thermistor can be soldered directly onto a printed-wiring board.
Robustness of terminations	
Tensile strength	20 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	
Free fall	1000 mm
Inflammability	Uninflammable

PACKAGING

600 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 288.

Current through the coil measured		
in circuit of Fig. 2 at 200 V r.m.s.		
min. inrush peak current		5 A
max. peak current		
after 5 s		70 mA
after 30 s		5 mA
after 3 min		2 mA
Resistance at +25 °C,		
R_s	~	40 Ω
R_p	~	3000 Ω
Maximum r.m.s. voltage in circuit *		265 V
Operating temperature range		
at zero power, complete assembly		−25 to +125 °C
at zero power, ceramic in free air (10 h max.)		−55 to +225 °C
at maximum voltage		0 to +60 °C

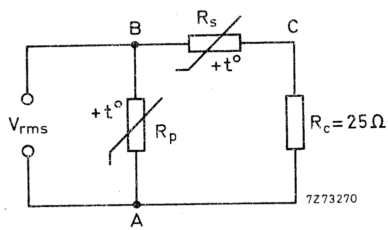


Fig. 2 Measuring circuit.

R_p = parallel PTC;
R_s = series PTC;
R_c = replaces the degaussing coil (Z = 25 Ω).

* In still air, the thermistor soldered on printed-wiring board.

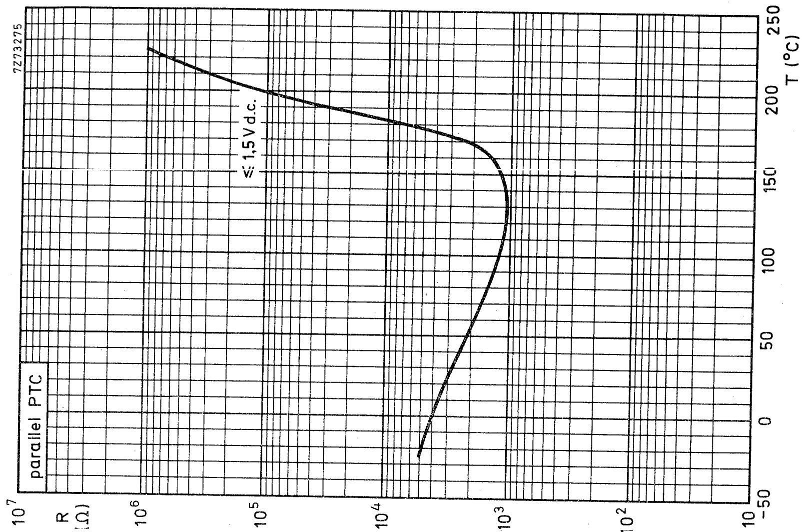


Fig. 4 Typical resistance versus temperature characteristics of the parallel PTC.

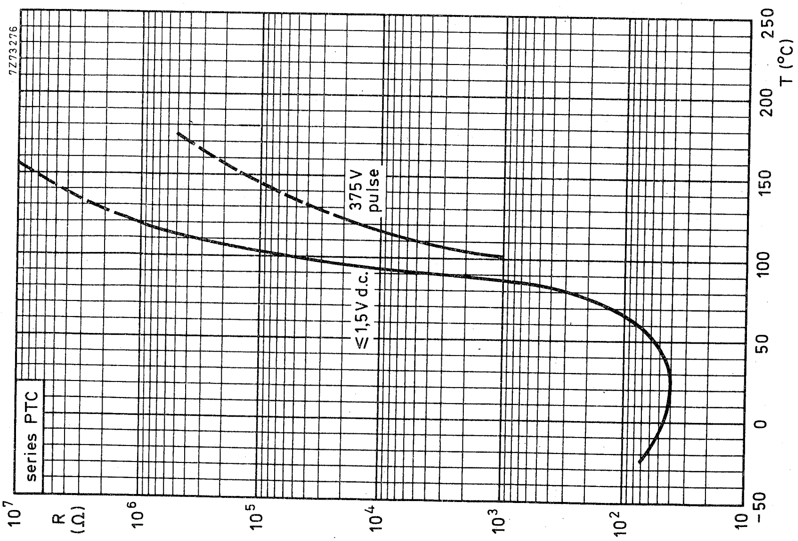


Fig. 3 Typical resistance versus temperature characteristics of the series PTC.

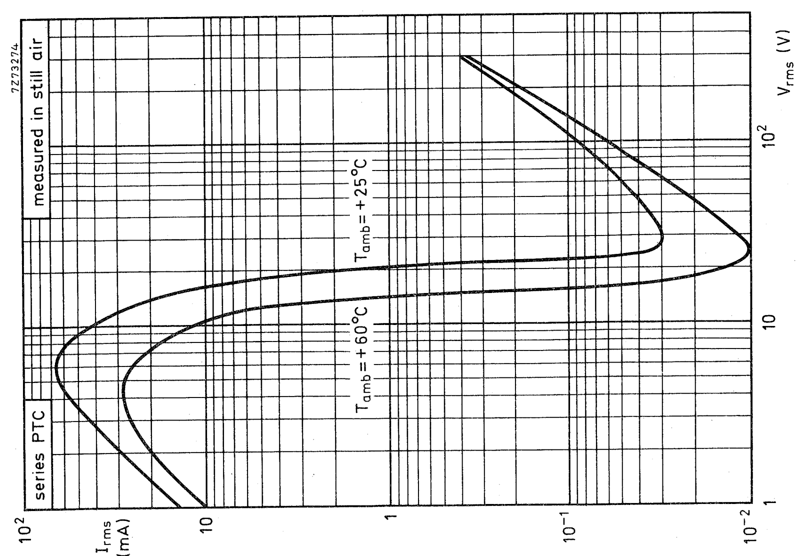


Fig. 5 Typical static current through the coil versus voltage characteristics.

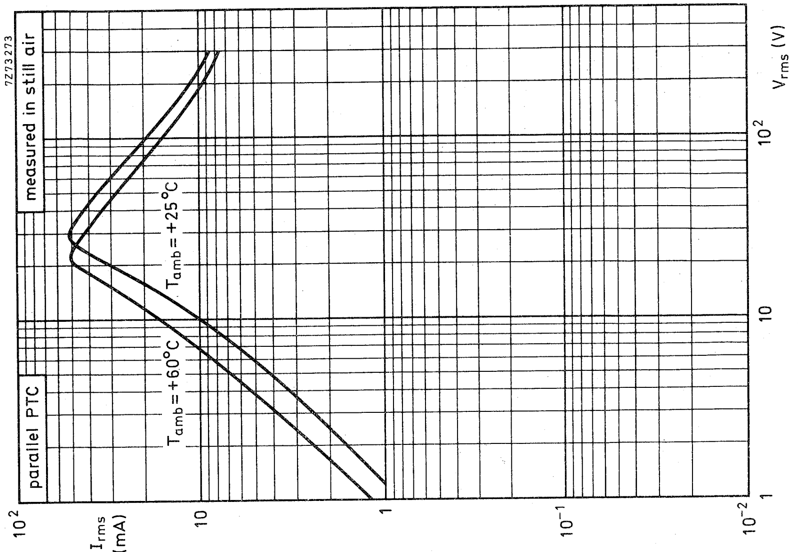


Fig. 6 Typical static current through the parallel PTC versus voltage characteristics.

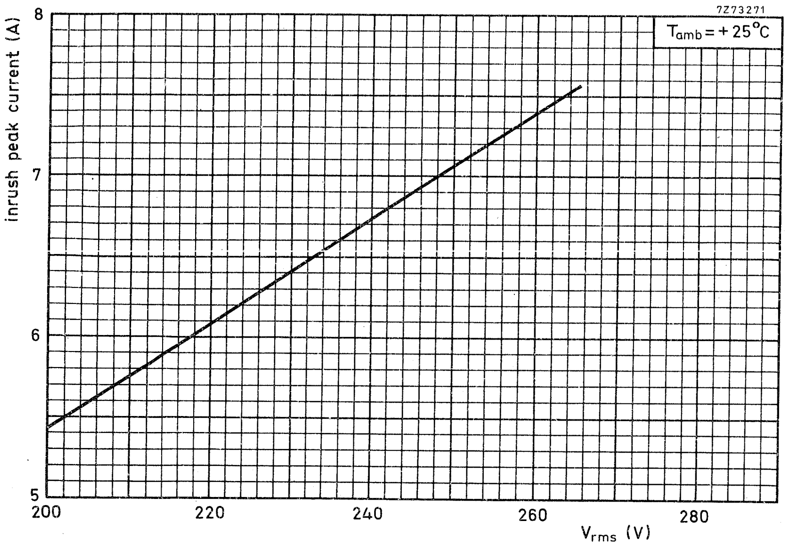


Fig. 7 Typical inrush peak current versus voltage characteristic.

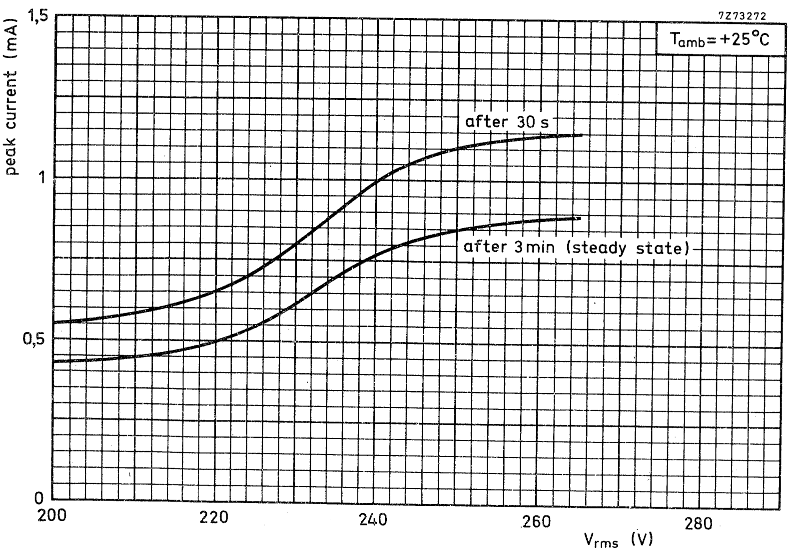


Fig. 8 Typical peak current versus voltage characteristics.

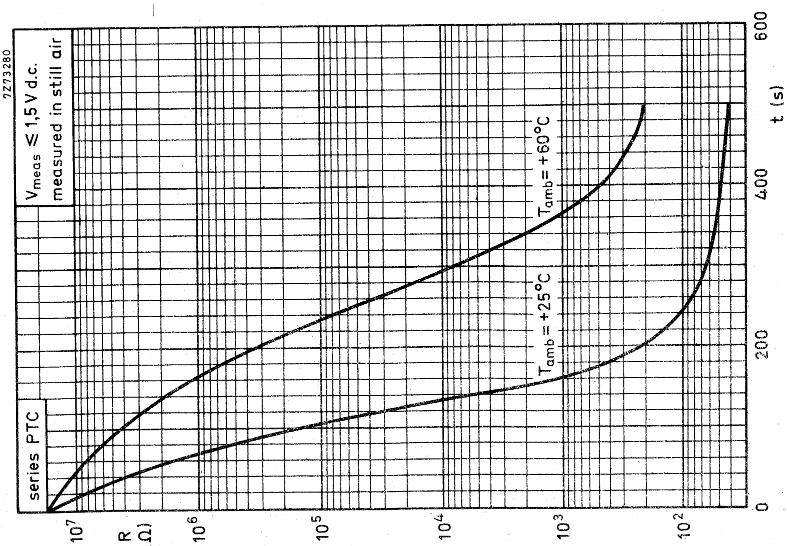


Fig. 9 Typical resistance versus cooling time characteristics of series PTC (cooling off after stationary operation at 220 V).

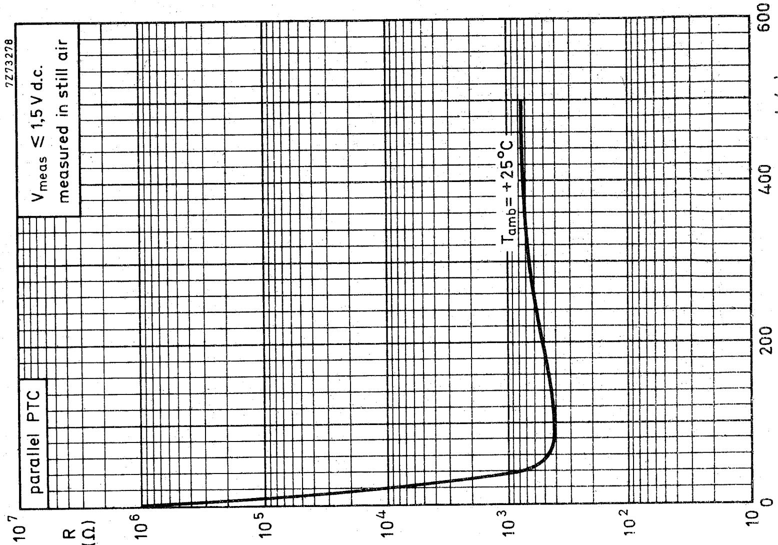


Fig. 10 Typical resistance versus cooling time characteristic of parallel PTC (cooling off after stationary operation at 220 V).

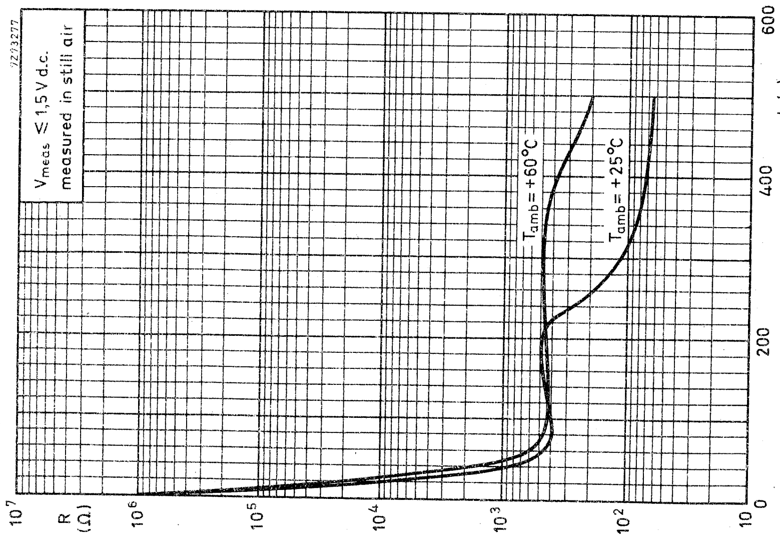


Fig. 11 Typical resistance of circuit versus cooling time characteristics (cooling off after stationary operation at 220 V).

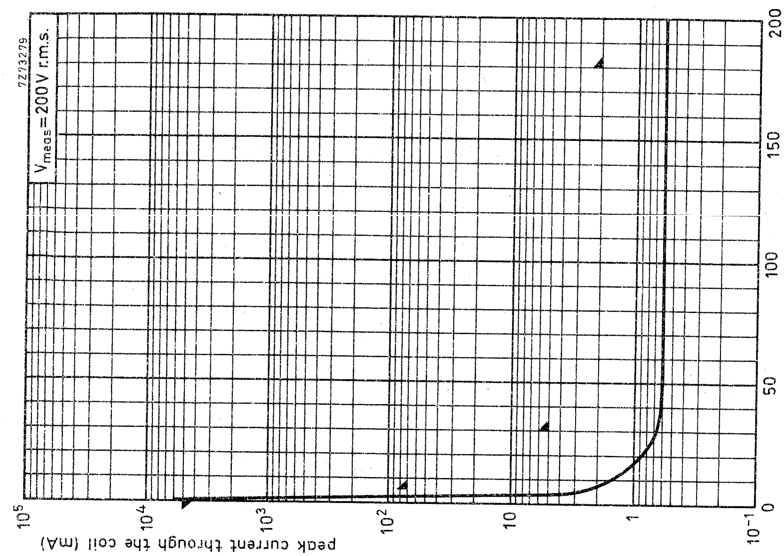


Fig. 12 Typical peak current through the coil versus time characteristic. Peak current limits are indicated by ◢.

DUAL PTC THERMISTOR

QUICK REFERENCE DATA

Current through the coil measured at 100 V r.m.s.	
min. inrush peak current	10 A
max. idle peak current	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	5 mA
Maximum voltage (r.m.s.)	145 V
Switch temperature	
of series PTC	+70 °C
of parallel PTC	+170 °C
Operating temperature range	
at zero power	−25 to +125 °C
at maximum voltage	0 to +60 °C

APPLICATION

In the degaussing circuit of colour television sets.

DESCRIPTION

The thermistor consists of two disc PTC thermistors clamped between stainless steel contacts. This assembly ensures a good thermal contact between both discs, which is essential for the function of this device. The thermistor is enclosed in a plastic housing. The three connecting pins are arranged to fit a printed-wiring board with a 0,1 inch grid.

MECHANICAL DATA

Outlines

A and B are to be connected to the mains;
A and C are to be connected to the degaussing coil (see Fig. 2).

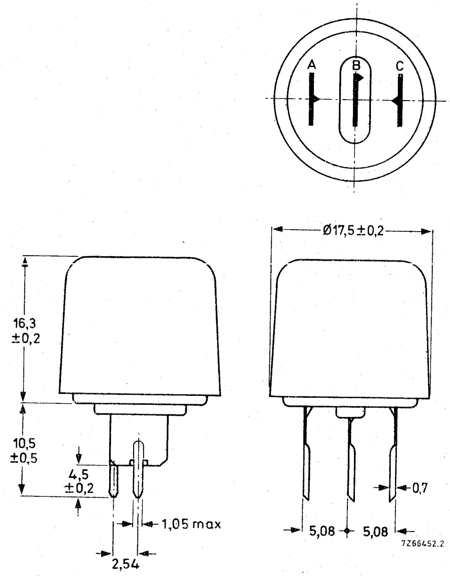


Fig. 1.

PACKAGING

500 thermistors in a cardboard box.

Marking	The catalogue number is moulded in the top of the cap
Mass	7,3 g approximately
Mounting	The thermistor can be soldered directly onto a printed-wiring board
Robustness of terminations	
Tensile strength	20 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s
Impact	
Free fall	1000 mm
Inflammability	Uninflammable, in accordance with MIL-STD-202, method 111.

ELECTRICAL DATA

All values are approximate unless otherwise specified.

Current through the coil measured in circuit of Fig. 2 at 100 V r.m.s.	
min. inrush current	10 A
max. idle peak current	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	5 mA
Resistance at +25 °C	
of series PTC	10 Ω
of parallel PTC	400 to 2400 Ω
at T_{amb} = +200 °C and 198 V pulsed	
of parallel PTC	> 10 kΩ
Switch temperature	
of series PTC	+70 °C
of parallel PTC	+170 °C
Temperature coefficient	
of series PTC	+16%/K
of parallel PTC	+20%/K
Maximum voltage (r.m.s.) in circuit of Fig. 2	145 V ←
Operating temperature range	
at zero power	−25 to +125 °C
at maximum voltage	0 to +60 °C

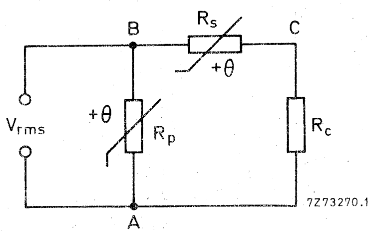


Fig. 2 Measuring circuit.

R_p = parallel PTC;
R_s = series PTC;
R_c = 6,2 Ω (replaces degaussing coil).

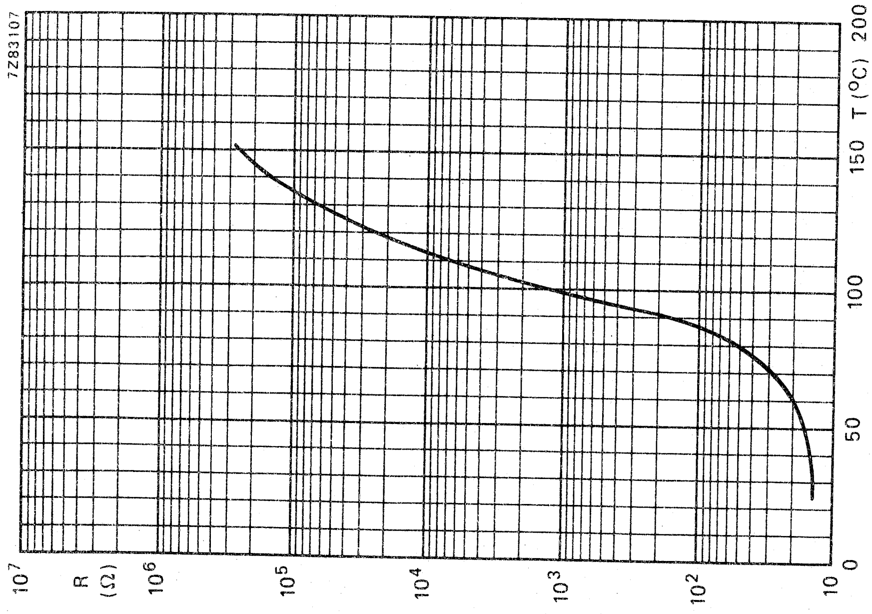


Fig. 3 Series PTC.

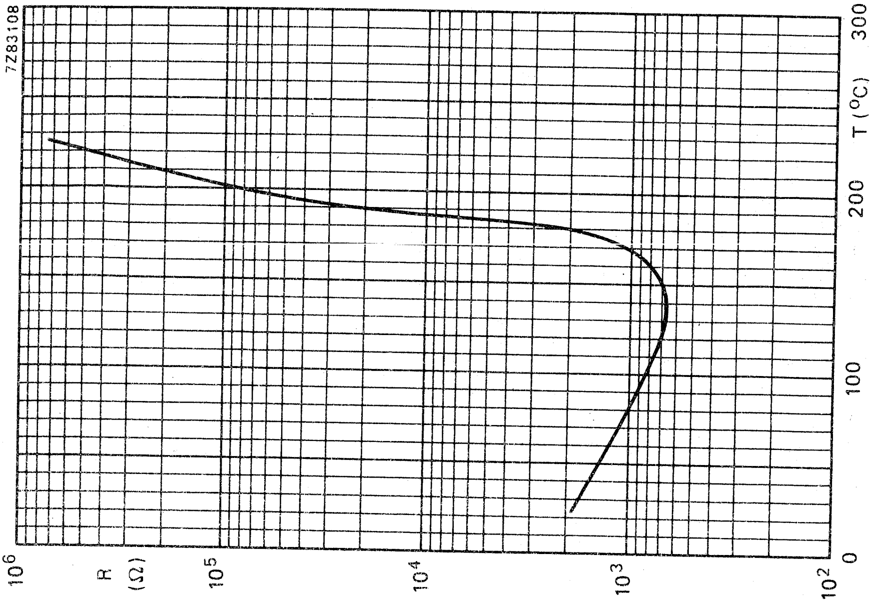


Fig. 4 Parallel PTC.

Typical resistance/temperature characteristics.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value at +25 °C	max. 1,1 Ω
Resistance value at +85 °C	max. 0,9 Ω
Switch temperature	+140 °C
Temperature coefficient	+8%/K
Maximum r.m.s. voltage	18 V
Operating temperature range	
at zero power	−25 to +175 °C
at maximum voltage	0 to +85 °C

APPLICATION
Overload protection, e.g. of loudspeakers.

DESCRIPTION
This positive temperature coefficient thermistor consists of a disc with two tinned brass wires.

MECHANICAL DATA
Outlines

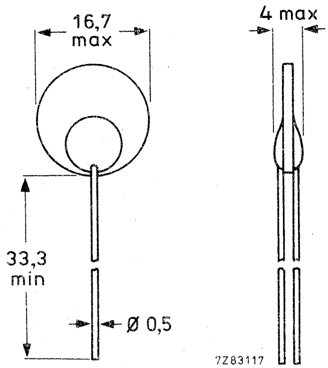


Fig. 1.

PACKAGING
2000 thermistors in a cardboard box.

Marking	none
Mass	1,25 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
Impact	200 mm free fall
Inflammability	uninflammable

ELECTRICAL DATA

Resistance at +25 °C	max. 1,1 Ω
Resistance at +85 °C	max. 0,9 Ω
Switch temperature	+140 °C approx.
Switching current at T_{amb} = +25 °C	max. 1,17 A
Max. current at which no switching occurs at T_{amb} = +25 °C	0,95 A
Temperature coefficient	+8%/K approx.
Maximum voltage (r.m.s.)	18 V
Steady state current at T_{amb} = +25 °C, V_{rms} = 18 V	max. 140 mA
Response time at T_{amb} = +25 °C, I = 2 A	max. 15 s
Operating temperature range	
at zero power	–25 to +175 °C
at maximum voltage	0 to +85 °C

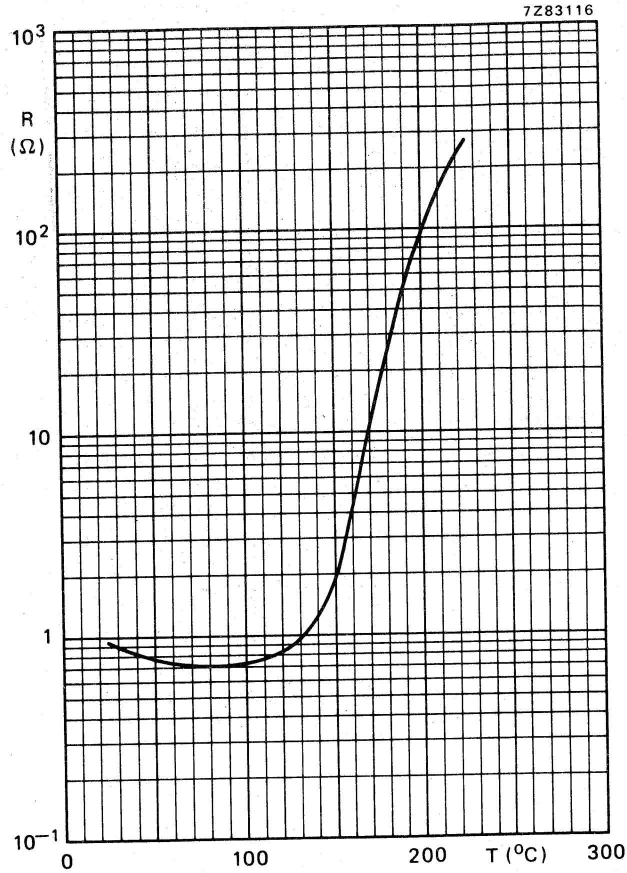


Fig. 2 Typical resistance/temperature characteristic.

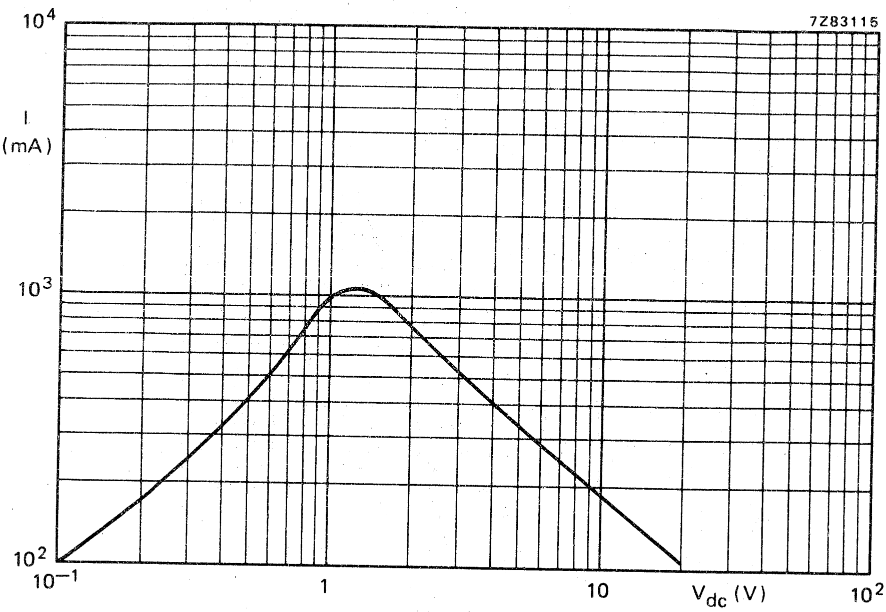


Fig. 3 Typical voltage/current characteristic.

PTC THERMISTOR

disc

QUICK REFERENCE DATA

Resistance value at +25 °C	max. 0,6 Ω
Resistance value at +150 °C V_{pulse} = 16 V	min. 40 Ω
Switch temperature	+85 °C
Temperature coefficient	+10%/K
Maximum d.c. voltage	16 V
Dissipation factor	27 mW/K
Operating temperature range at zero power at V_{max}	 −25 to +155 °C −25 to +55 °C

APPLICATION

Overload protection, e.g. of relay coils, loudspeakers, etc.

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

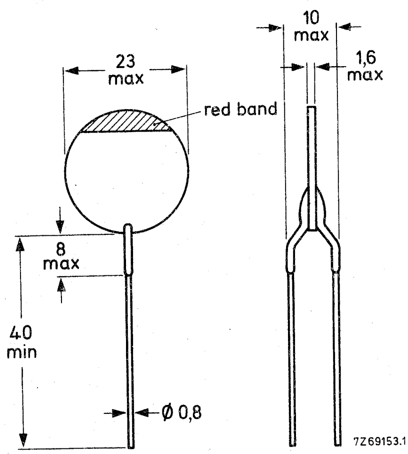


Fig. 1.

PACKAGING

100 thermistors in a cardboard box.

Marking	The thermistors are marked with a red band.
Mass	~ 2,3 g
Mounting	In any position by soldering
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

ELECTRICAL DATA

Resistance at −25 °C	max. 1,15 Ω *	
Resistance between +25 and +55 °C	max. 0,6 Ω *	
Resistance at +150 °C V_{pulse} = 16 V	min. 40 Ω **	
Switch temperature	~ +83 °C	
Temperature coefficient	~ 10%/K	
Dissipation factor	~ 27 mW/K	***
Heat capacity	~ 1,2 J/K	***
Thermal time constant	~ 45 s	***
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum voltage	−25 to +55 °C	
Maximum voltage (d.c.)	16 V	

* D.C. measuring voltage not exceeding 1,5 V to avoid internal heating.
** Measurement made without internal heating.
*** Measurements made with specimen in phosphor bronze clips, in still air.

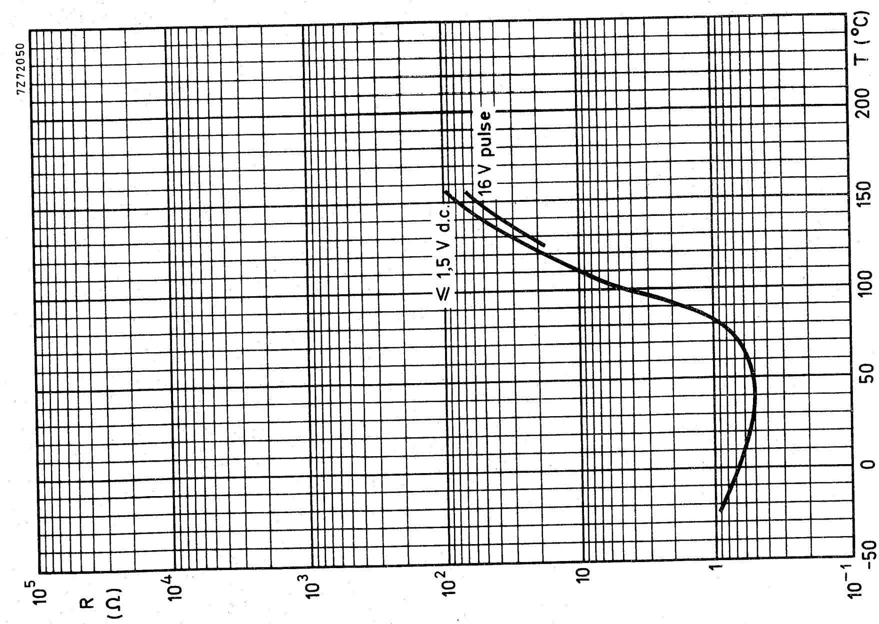


Fig. 2 Typical resistance/temperature characteristics.

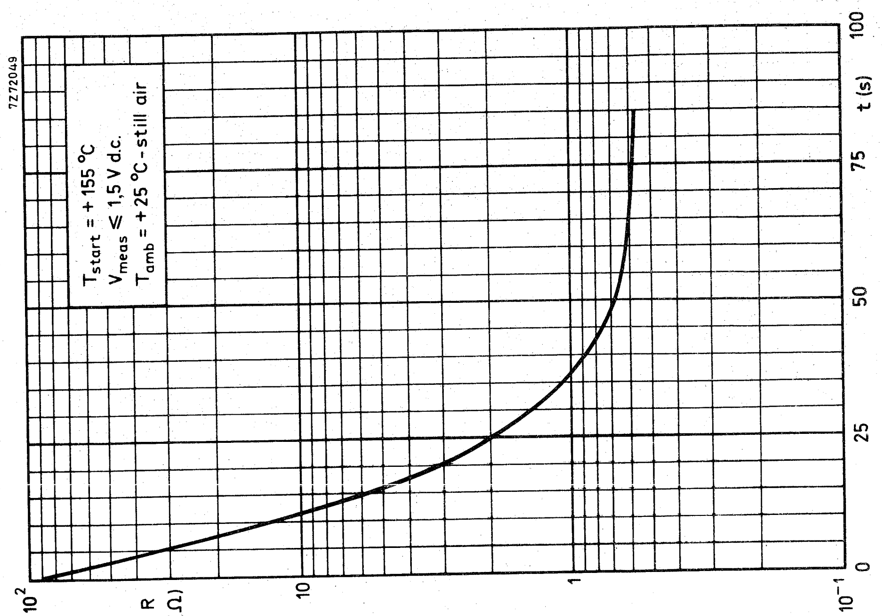


Fig. 3 Typical resistance/time (cooling) characteristic.

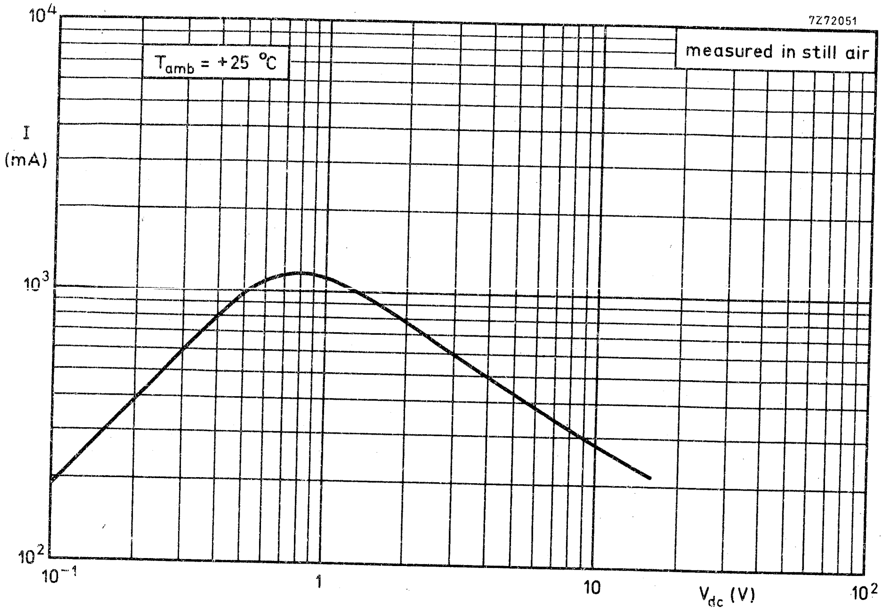


Fig. 4 Typical voltage/current characteristic.

PTC THERMISTOR

QUICK REFERENCE DATA

Resistance	
at +25 °C	120 ± 30 Ω
at +155 °C	> 2 kΩ
Switch temperature	≈ 145 °C
Temperature coefficient	> 8%/K
Maximum voltage (d.c.) at +40 °C	34 V
Response time	⩽ 2 S
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	0 to +40 °C

APPLICATION

Current stabilizer for compensation of variation in telephone line resistance.

DESCRIPTION

A miniature thermistor element mounted in a glass envelope model SOD-27 with two axial leads.

MECHANICAL DATA

Outlines

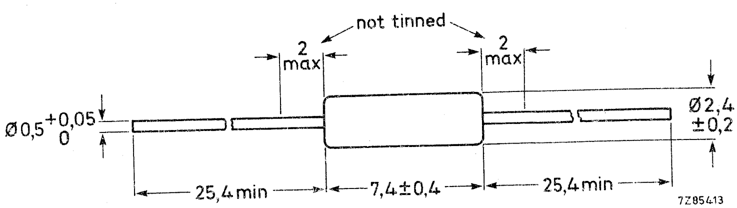
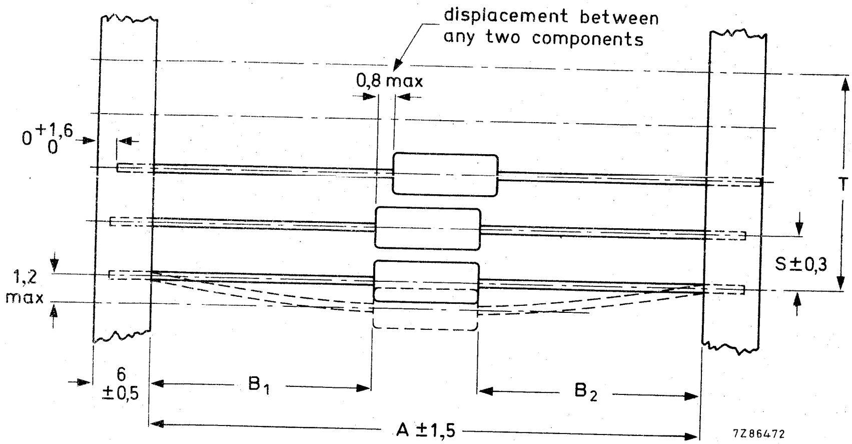


Fig. 1.

STANDARD PACKAGING

The thermistors are supplied in quantities of 5000 on bandolier which is zig-zag folded in an ammopack.

Configuration of banodlier



style	A	$B_1 - B_2$ ± max.	S (spacing)	T (max. deviation of spacing)
TPJ	53	1,2	5	2 mm for 10 spacings, 1,5 mm fpr 5 spacings

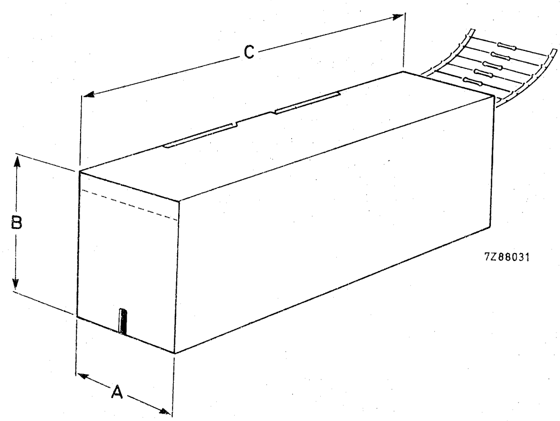


Fig. 3 Dimensions of ammopack in mm.

A = 75 mm
B = 95 mm
C = 270 mm

PTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance value between –20 and (T_s – 10) °C	30 to 250 Ω
Resistance value at (T_s + 25) °C and V_{pulse} = 7,5 V	⩾ 4000 Ω
Switch temperature, T_s	70 to 150 °C
Temperature coefficient	18 to 38%/K
Maximum voltage (d.c.)	25 V
Dissipation factor (version with leads)	5,7 mW/K
Operating temperature range	
at zero power	–25 to (T_s + 40) °C
at maximum voltage	0 to (T_s + 25) °C

APPLICATION

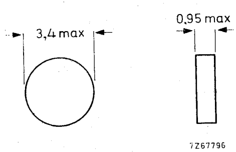
Temperature sensors in domestic appliances, fire alarms, car electronics, etc.

DESCRIPTION

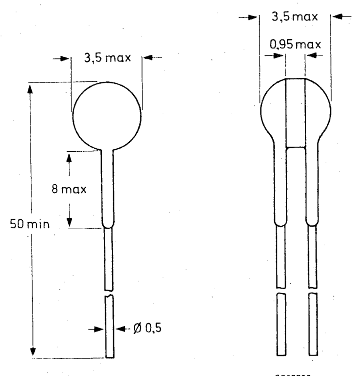
These thermistors have a positive temperature coefficient. They consist of a disc with or without two tinned copper wires. The thermistor without leads is not lacquered nor insulated. The thermistor with leads is lacquered but not insulated.

MECHANICAL DATA

Outlines



version without leads.



version with leads

Fig. 1.

Marking

Version without leads	none
Version with leads	colour code, see table

Mass

Version without leads	0,04 g approx.
Version with leads	0,29 g approx.

Mounting (for version with leads only)

In any position by soldering.

Robustness of terminations (for version with leads only)

Tensile strength	10 N
Bending	5 N

Soldering (for version with leads only)

Solderability	max. 240 ^{o}C, max. 4 s
Resistance to heat	max. 265 ^{o}C, max. 11 s

Impact

Free fall

PACKAGING

Version without leads: 2000 thermistors in a cardboard box.
Version with leads: 500 thermistors in a cardboard box.

ELECTRICAL DATA

All values in the electrical data without further indication are approximate values.

T_s	temperature coefficient	balance voltage	voltage dependence β	colour code for version	catalogue number 2322 672	
°C	%/K	V d.c.	at (T_s + 25) °C	with leads	with leads	without leads
70	18	19	0,32	violet	91002	91026
80	21	27	0,40	grey	91003	91027
90	31	16	0,36	white	91004	91028
100	33	17	0,35	black	91005	91029
110	38	11	0,36	brown	91006	91031
120	27	34	0,38	red	91007	91032
130	33	13	0,34	orange	91008	91033
140	33	20	0,35	yellow	91009	91034
150	23	20	0,31	green	91011	91035

Resistance value between −20 and (T_s − 10) °C	30 to 250 Ω *
Resistance value at (T_s + 5) °C	⩽ 550 Ω *
Resistance value at (T_s + 15) °C	⩾ 1330 Ω *
Resistance value at (T_s + 25) °C, V_{pulse} = 7,5 V	⩾ 4000 Ω **
Maximum voltage (d.c.)	25 V
Dissipation factor (version with leads)	5,7 mW/K
Thermal time constant (version with leads)	9 s
Heat capacity (version with leads)	0,05 J/K
Operating temperature range	
at zero power	−25 to (T_s + 40) °C
at maximum voltage	0 to (T_s + 25) °C

* Measuring voltage not exceeding 2,5 V d.c. to avoid internal heating.
** Measurements made without internal heating occurring.

Typical resistance/temperature characteristics

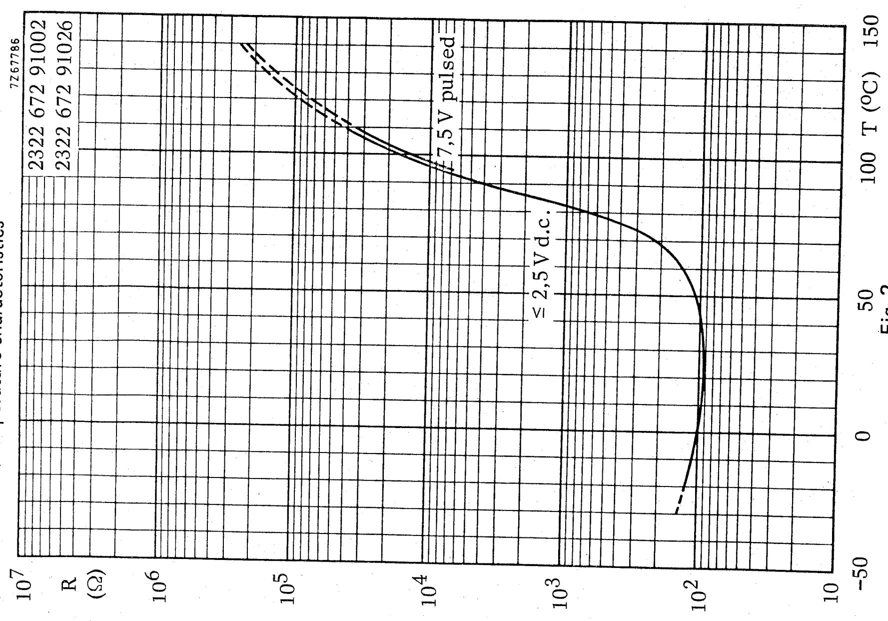


Fig. 2.

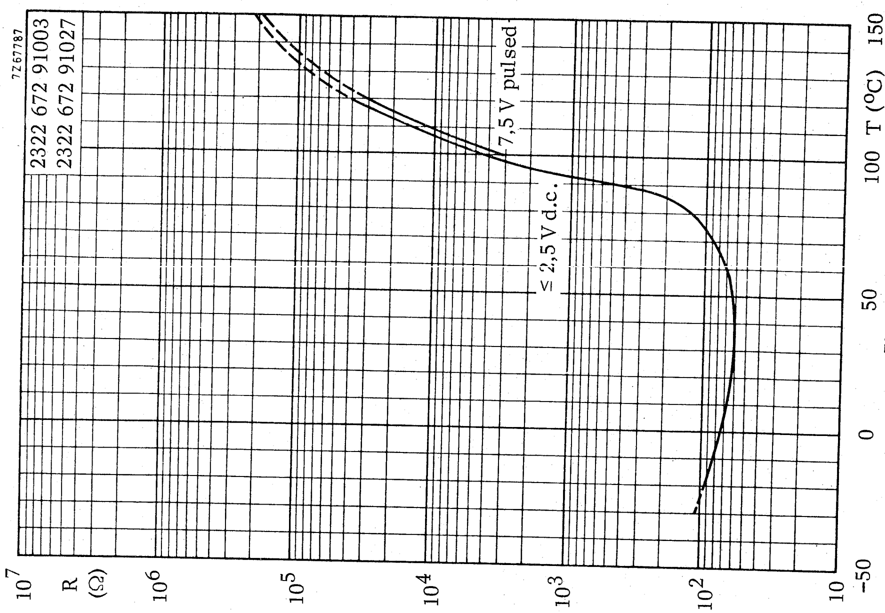


Fig. 3.

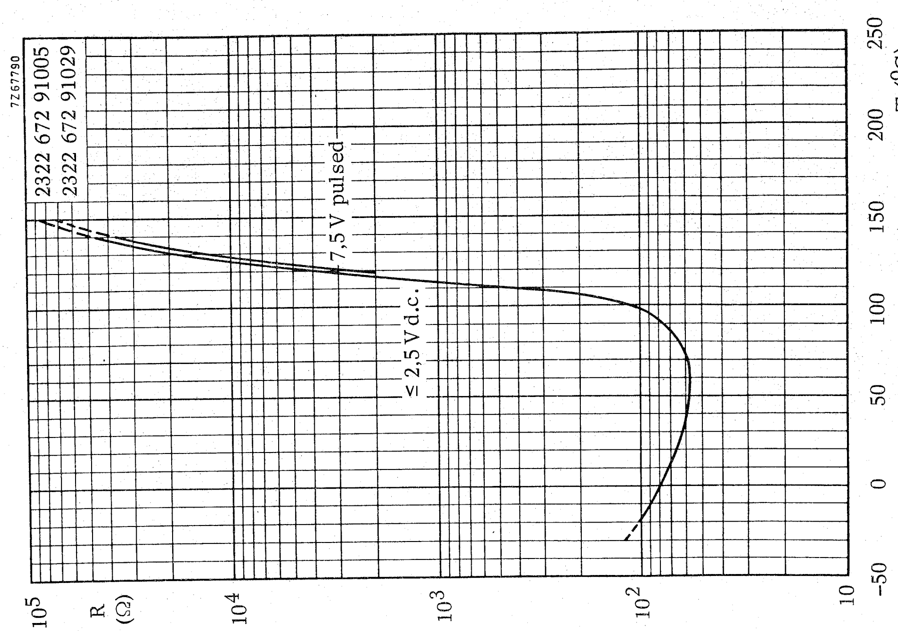

7Z67790
2322 672 91005
2322 672 91029
7,5 V pulsed
≤ 2,5 V d.c.
10^5
R
(Ω)
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 5.

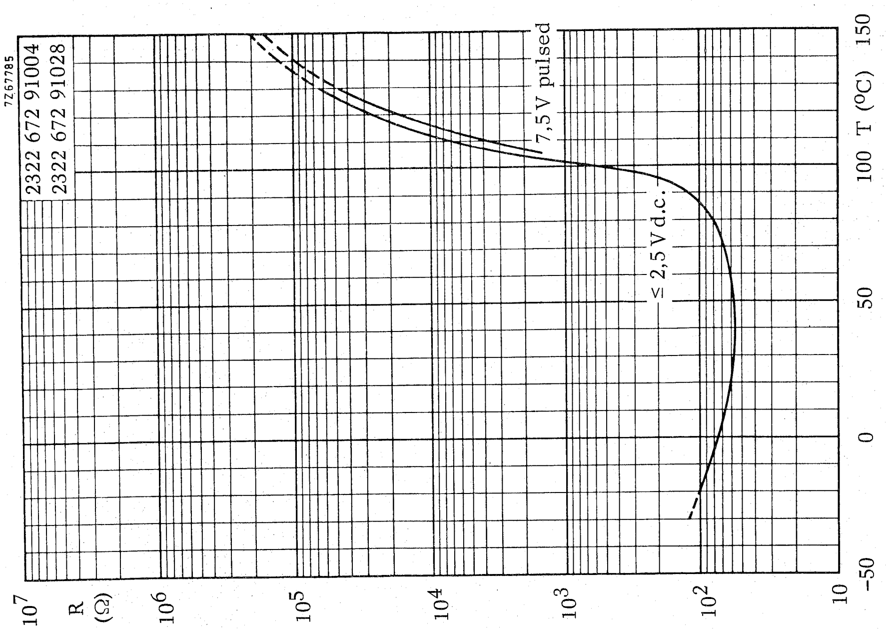

7Z67785
2322 672 91004
2322 672 91028
7,5 V pulsed
≤ 2,5 V d.c.
10^7
R
(Ω)
10^6
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
T (°C)

Fig. 4.

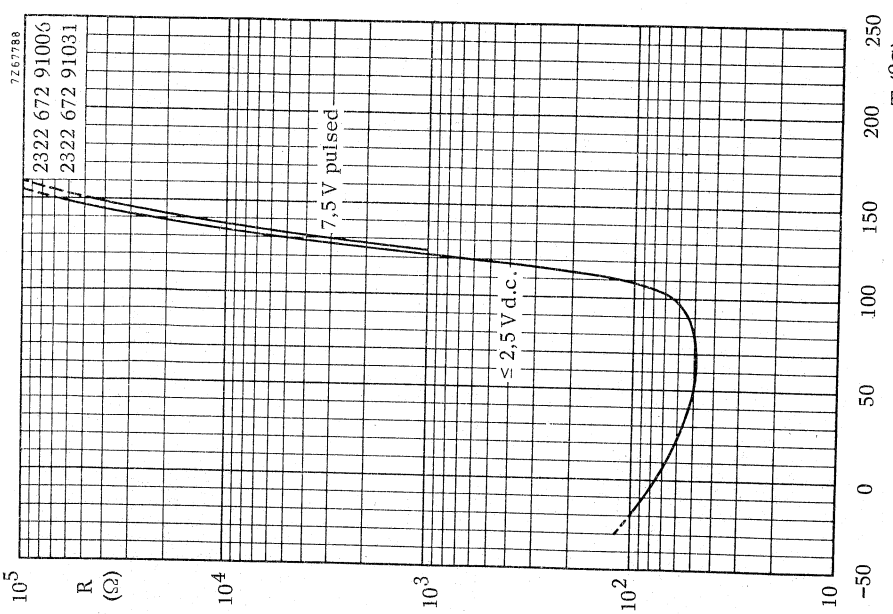

7Z67788
2322 672 91006
2322 672 91031
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 6.

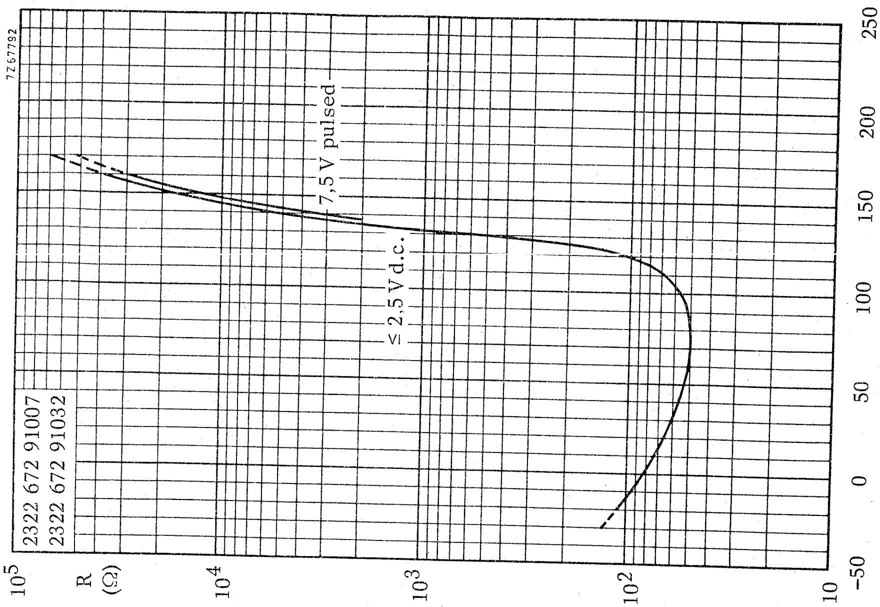

7Z67792
2322 672 91007
2322 672 91032
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 7.

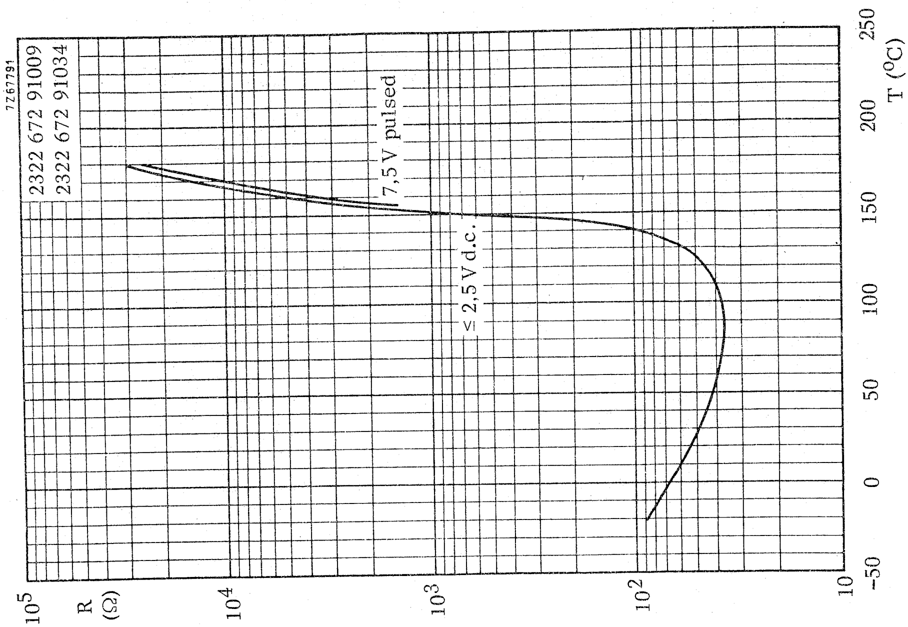

7Z67791
2322 672 91009
2322 672 91034
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 9.

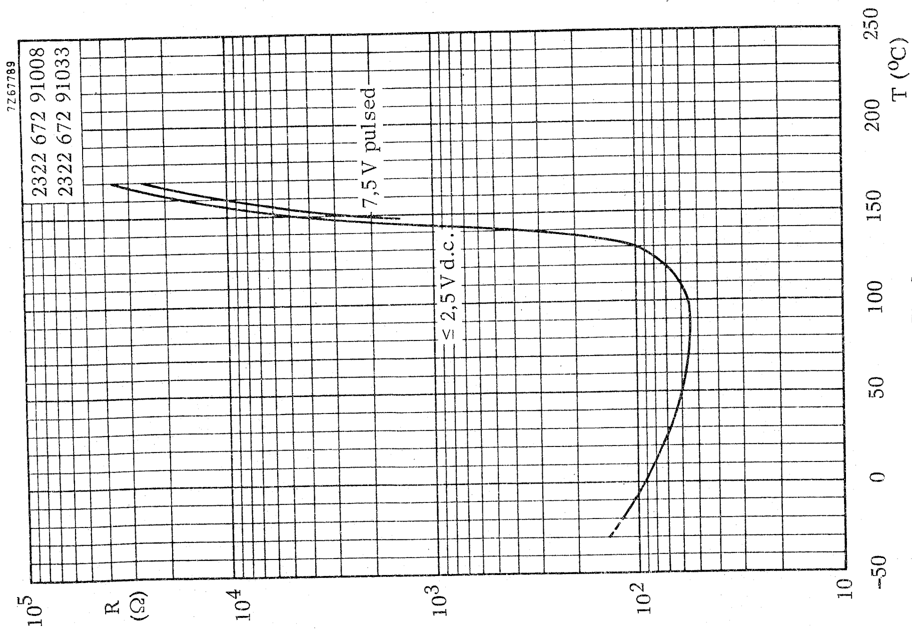

7Z67789
2322 672 91008
2322 672 91033
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 8.

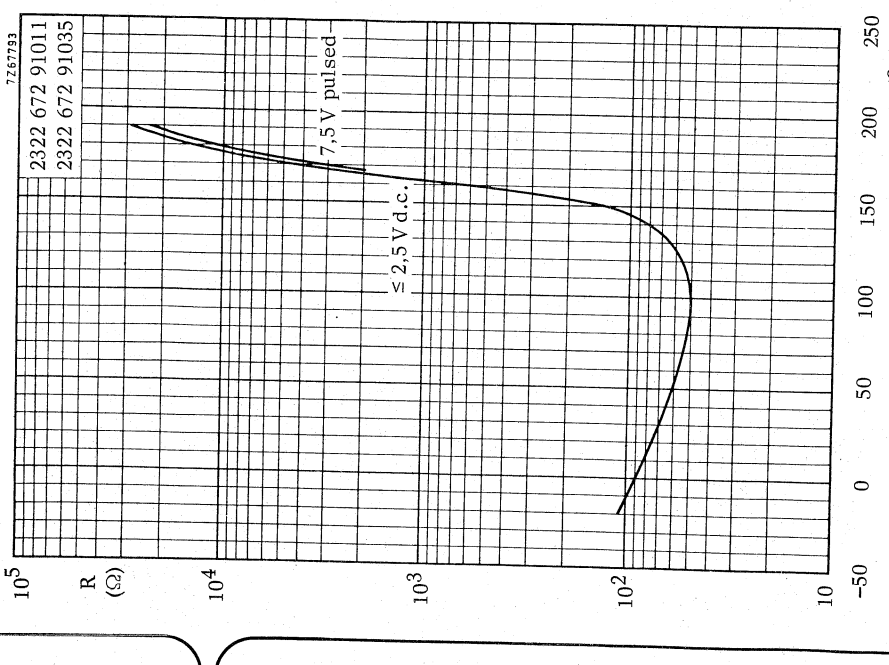


Fig. 10.

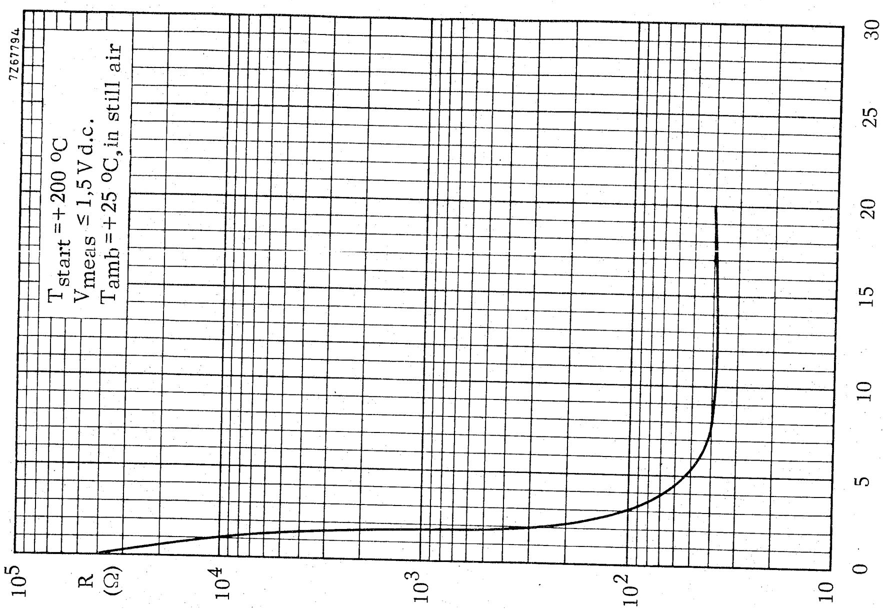


Fig. 11 Typical resistance/time (cooling) characteristic.

PTC THERMISTORS

for motor protection

QUICK REFERENCE DATA

Resistance value at −20 and T_{ref} −20 °C	30 to 250 Ω
Resistance value at T_{ref} + 15 °C, V_{pulse} = 7,5 V	> 4000 Ω
Maximum voltage (d.c.)	15 V
Switch temperature, T_s	68 to 137 °C
Dissipation factor	≈ 7 mW/K
Operating temperature range	
at zero power	−20 to T_{ref} + 30 °C
at V_{max}	−20 to T_{ref} + 15 °C

APPLICATION

These thermistors have been designed for use in transistorized circuits for the protection of electric motors against overheating. They are to be built into the windings of the stator (one PTC thermistor per phase).

DESCRIPTION

The thermistors have a positive temperature coefficient. They consist of a disc with two tinned copper "Litze" wires with a cross-section not greater than 7/0,0076 inch (0,194 mm) and insulated with PTFE material complying with the requirements of the ministry of aviation specification EL1930.

MECHANICAL DATA

Outlines

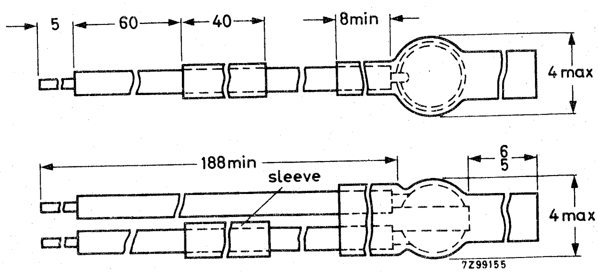


Fig. 1.

Marking The last five figures of the catalogue number are printed on the sleeve, e.g. PTC 92046.

Mass 1,6 g approximately

Mounting In motor windings; connections to be soldered or clamped.

PACKAGING

500 thermistors in a cardboard box.

ELECTRICAL DATA

T_{ref} °C (note 1)	T_s °C	temperature coefficient %/K	voltage dependence β	balance voltage V_{dc}	catalogue number
80	68	18	0,32	19	2322 672 92045
90	75	21	0,40	27	92046
100	88	31	0,36	6,5	92047
110	99	33	0,35	17	92048
120	113	38	0,36	11	92049
130	123	27	0,38	34	92051
140	130	33	0,34	13	92052
150	137	33	0,35	20	92053

		notes
Resistance between −20 and T_{ref} − 20 °C	30 to 250 Ω	2
Resistance at T_{ref} −5 °C	< 550 Ω	2
Resistance at T_{ref} +5 °C	> 1330 Ω	
Resistance at T_{ref} + 15 °C, V_{pulse} = 7,5 V	> 4000 Ω	3
Dissipation factor	≈ 7 mW/K	4
Heat capacity	≈ 0,1 J/K	4
Thermal time constant	≈ 14 s	4
Response time	⩽ 8 s	5
Operating temperature range		
at zero power	−20 to + T_{ref} +30 °C	
at V_{max}	−20 to + T_{ref} + 15 °C	
Maximum voltage (d.c.)	15 V	
Dielectric withstanding voltage (r.m.s.) between terminals and lead insulation	⩾ 2500 V	
Insulation resistance between terminals and lead insulation	⩾ 100 MΩ	

Notes

1. T_{ref} is the temperature at which the thermistor has to make the protective system operative.
2. Measuring voltage not exceeding 1,5 V(d.c.) to avoid internal heating.
3. Measurements made without internal heating occurring.
4. Measurements made with specimen in phosphor-bronze clips, in still air.
5. Response time is the time in which the thermistor-body temperature rises to 63,2% of the difference between initial and final body temperature, when the thermistor is subjected to a step function change in ambient temperature.
   Initial temperature: 25 °C (air).
   Final temperature: T_{ref} + 15 °C (silicon oil MS 200/50).

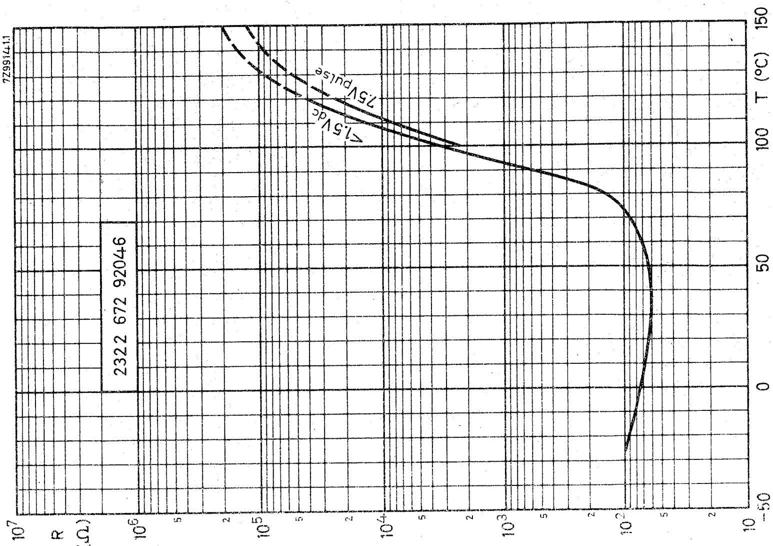


Fig. 3.

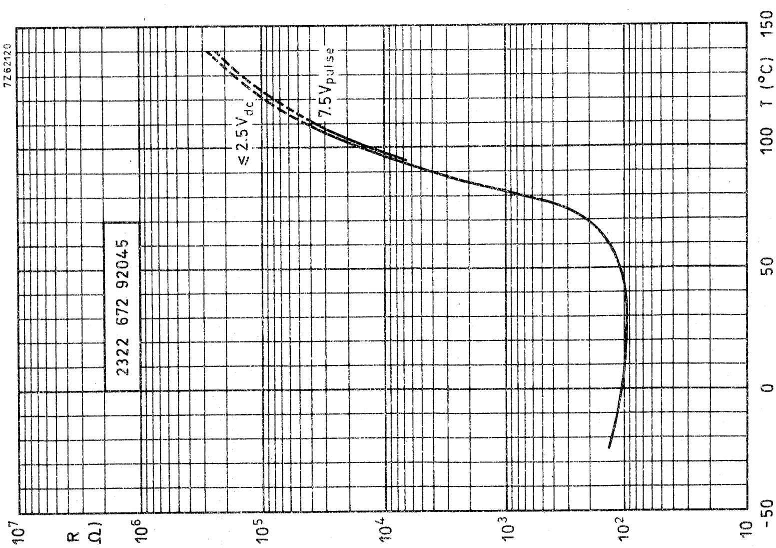


Fig. 2.

Typical resistance/temperature characteristics.

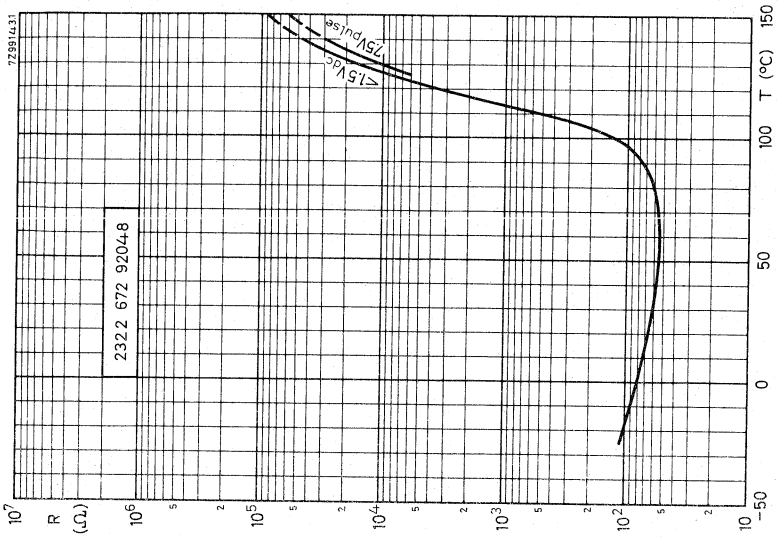


Fig. 5.

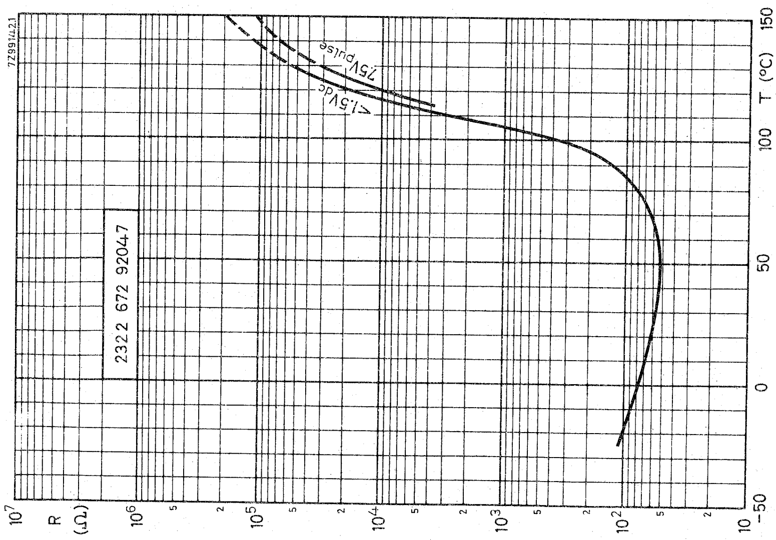


Fig. 4.

Typical resistance/temperature characteristics.

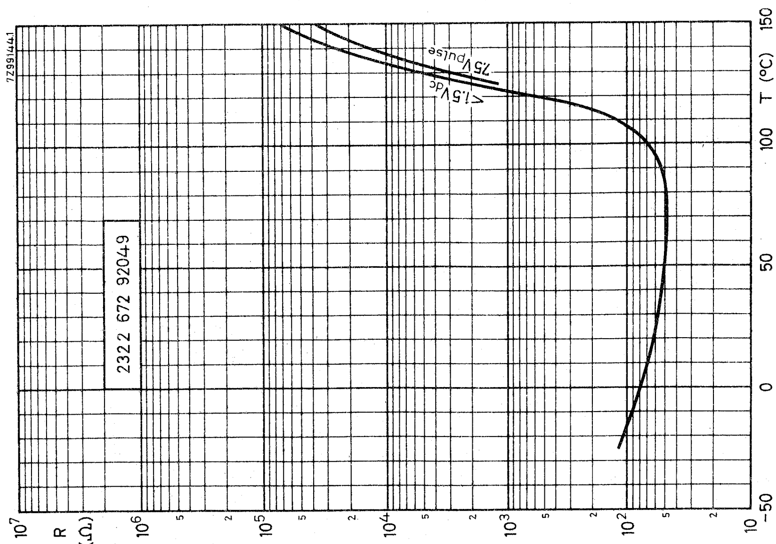


Fig. 6.

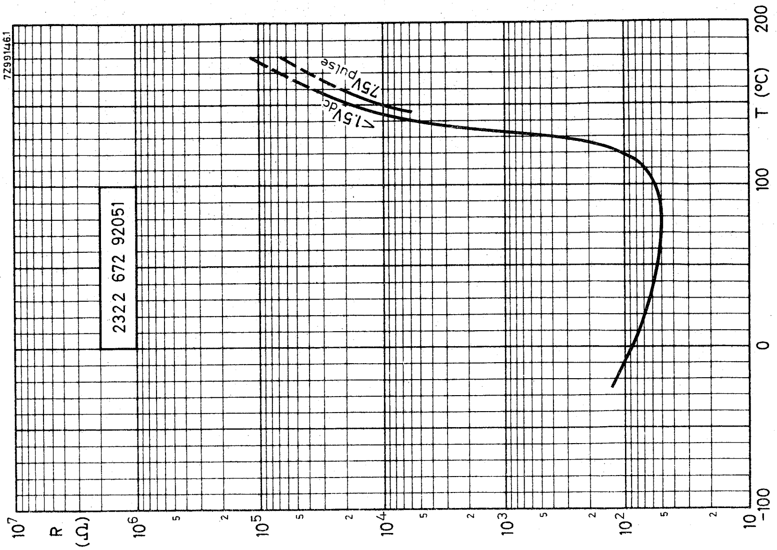


Fig. 7.

Typical resistance/temperature characteristics.

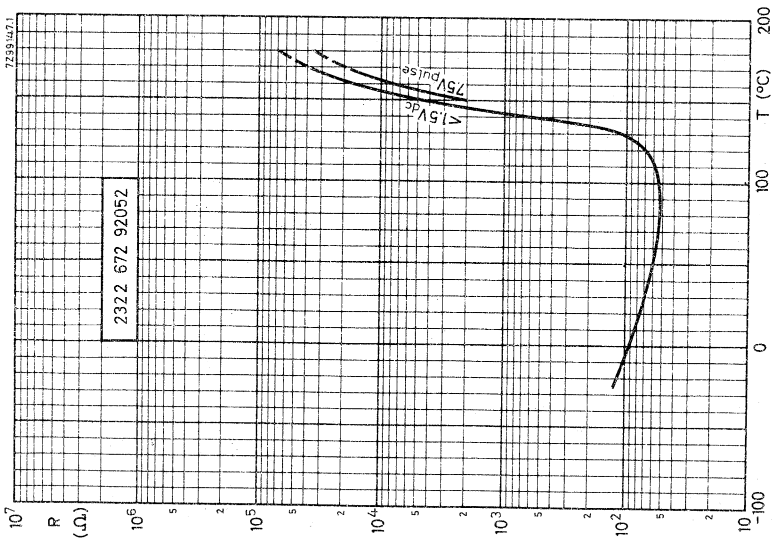


Fig. 8.

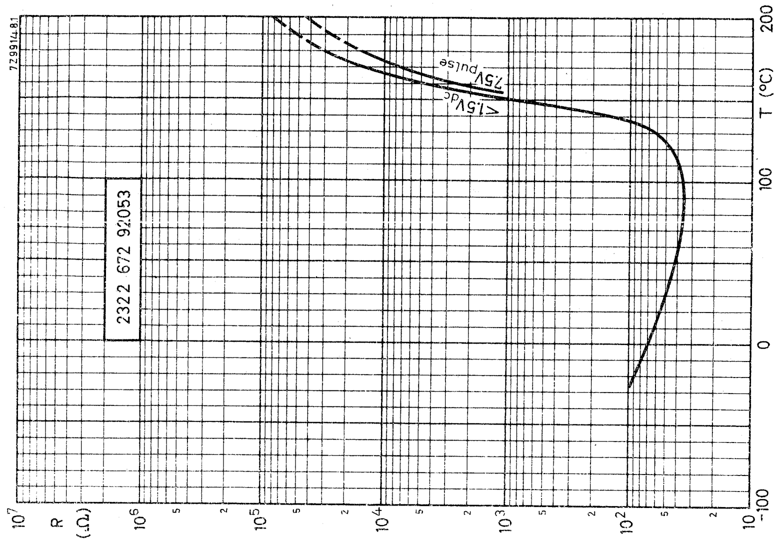


Fig. 9.

Typical resistance/temperature characteristics.

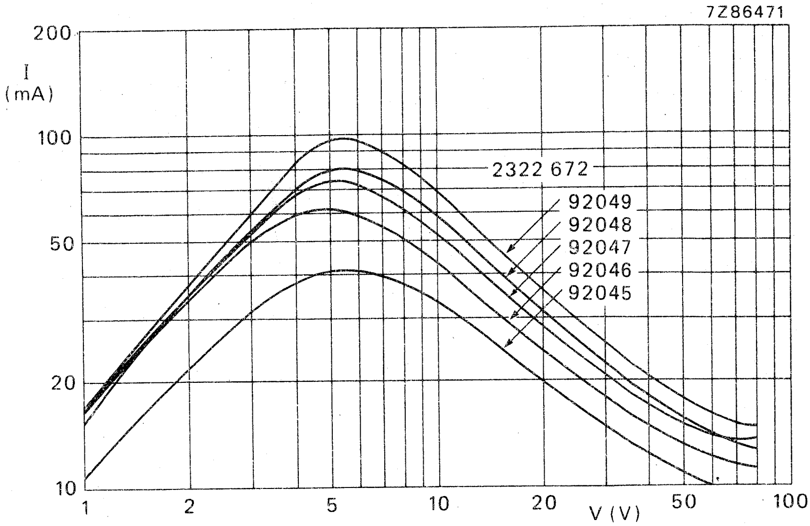


Fig. 10.

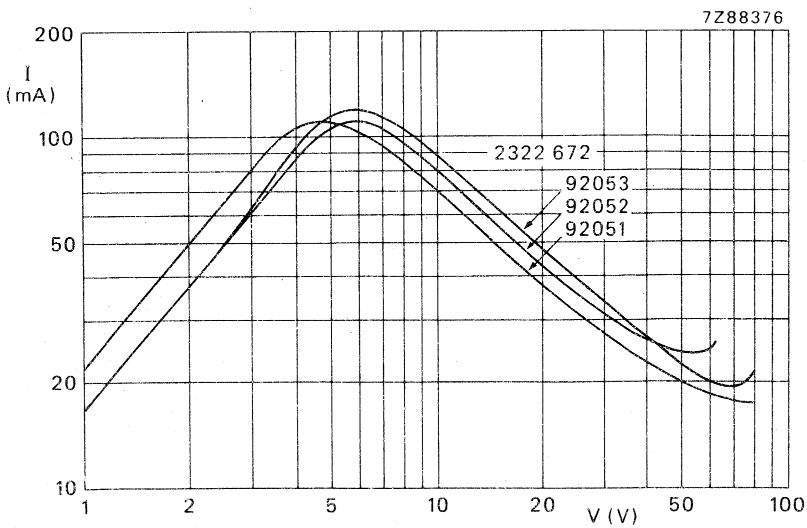


Fig. 11.

Typical voltage/current characteristics.

PTC THERMISTOR

QUICK REFERENCE DATA

Resistance value at + 25 °C	115 ± 25 Ω
Resistance value at + 155 °C, V_{pulse} = 33 V	min. 15 kΩ
Switch temperature	≈ + 97 °C
Temperature coefficient	min. 10%/K
Maximum voltage (d.c.)	33 V
Oerating temperature range	
at zero power	−25 to + 155 °C
at maximum voltage	+ 5 to + 55 °C

APPLICATION

As current stabilizer for compensation of variations in telephone line resistance.

DESCRIPTION

Disc with positive temperature coefficient, mounted between pressure contacts to ensure a long cycle life. Provided with two silvered pins for mounting in a printed-wiring board. Plastic encapsulation.

MECHANICAL DATA

Outlines

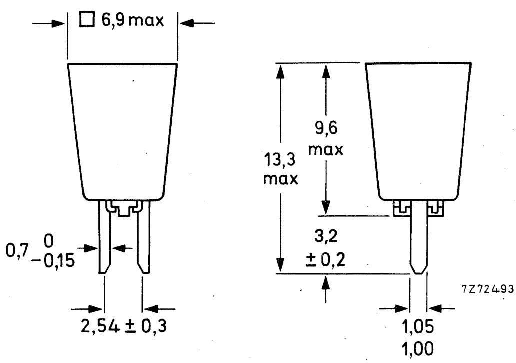


Fig. 1.

PACKAGING

5000 thermistors in a cardboard box (containing 10 foam plastic trays).

Marking

Manufacturer's identification symbol and the letters TPE, representing the model, are moulded in the top of the cap.

Mass	0,4 g approximately
Mounting	to be soldered onto a printed-wiring board

Robustness of terminations

Tensile strength	10 N

Soldering

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

Vibration	in accordance with CCTU 01-01A fasc. 16 A severity 55 A

Impact

Free fall	1000 mm
Inflammability	uninflammable

ELECTRICAL DATA

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

Resistance	
at +25 °C	115 ± 25 Ω
at +97 °C	max. 600 Ω
at +155 °C, V_{pulse} = 33 V	min. 15 000 Ω
Switch temperature	+97 °C
Temperature coefficient	min. +10%/K
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	+5 to +55 °C
Voltage dependence at +155 °C	0,29
Maximum voltage (d.c.)	33 V

Maximum dielectric withstanding voltage (r.m.s.) between terminals and capsule	500 V
Insulation resistance between terminals and capsule at 100 V d.c.	min. 10 MΩ

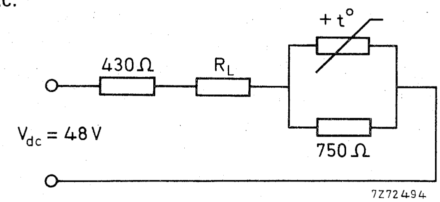
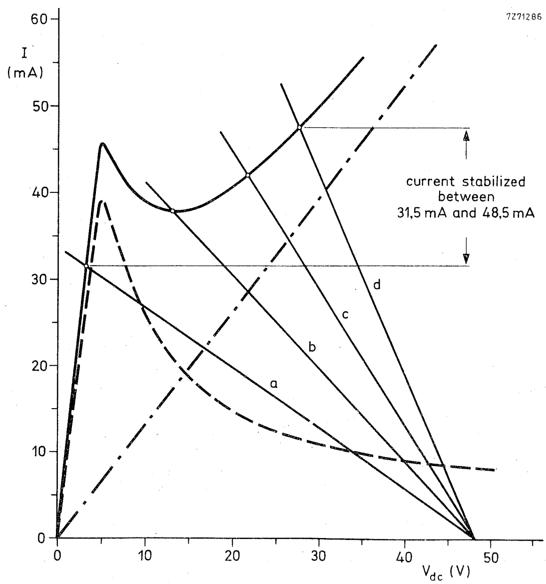


Fig. 2 Line resistance (R_L) compensation.

Initial current of +5 °C and R_L = 0	min. 75 mA max. 95 mA
Current after 10 s at +5 °C and R_L = 0	max. 60 mA
Initial current at +55 °C and R_L = 0	min. 85 mA max. 105 mA
Current after 10 s at +5 °C and R_L = 0	max. 55 mA



PTC + parallel-connected 750 Ω resistor;
PTC alone;
750 Ω resistor alone.

Fig. 3 (a) R_L = 1000 Ω; (b) R_L = 500 Ω; (c) R_L = 200 Ω; (d) R_L = 0 Ω.

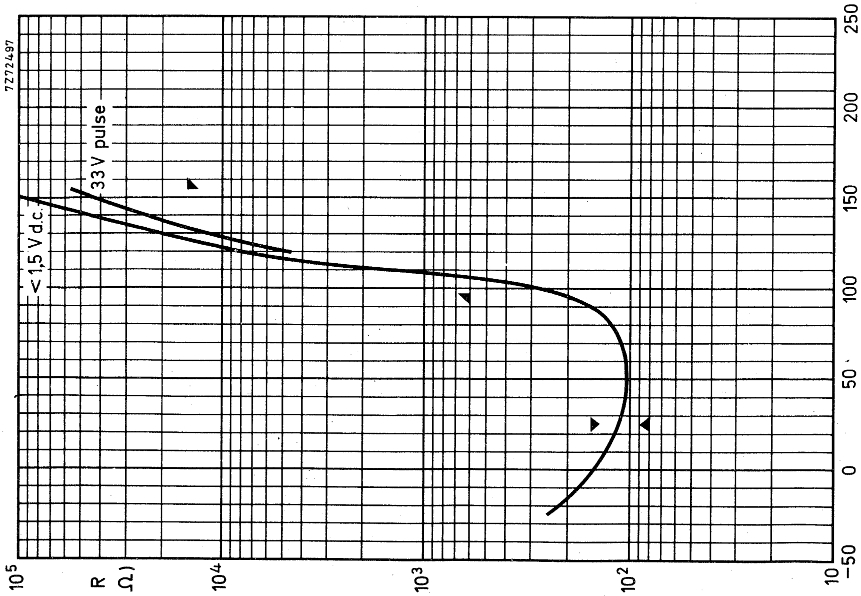


Fig. 4 Typical resistance/temperature characteristics.

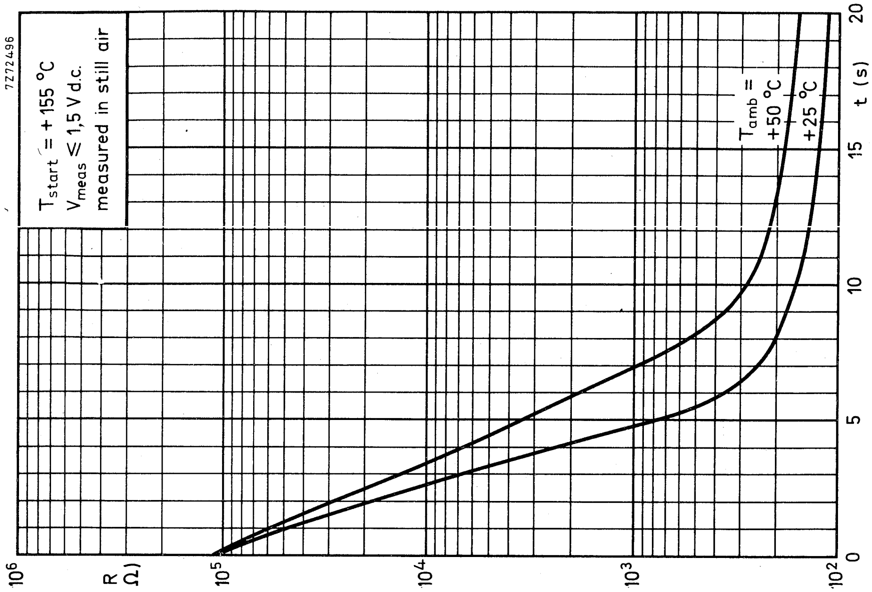


Fig. 5 Typical resistance/time (cooling) characteristics.

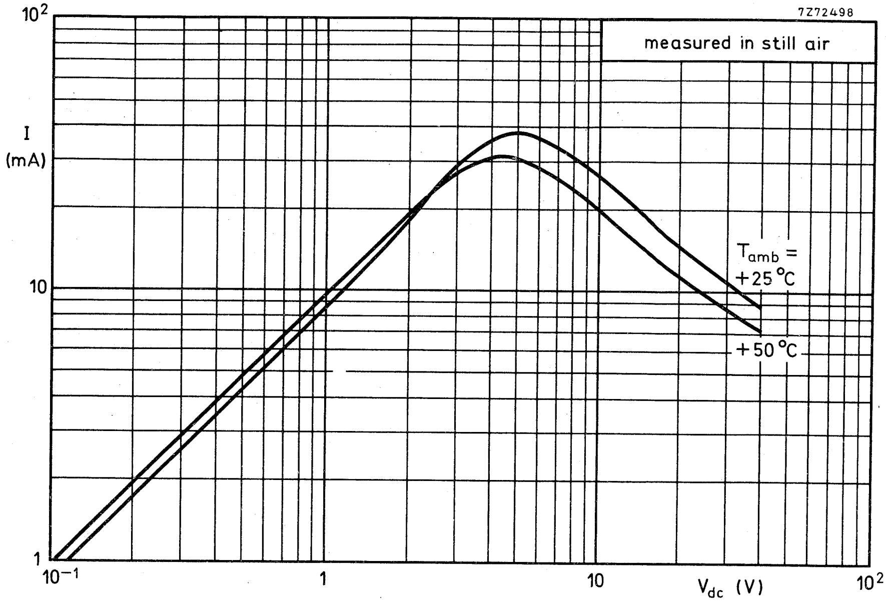


Fig. 6 Typical voltage/current characteristics.

Note:

Figs 5, 6 and 7 are measured with the PTC mounted on a printed-wiring board.

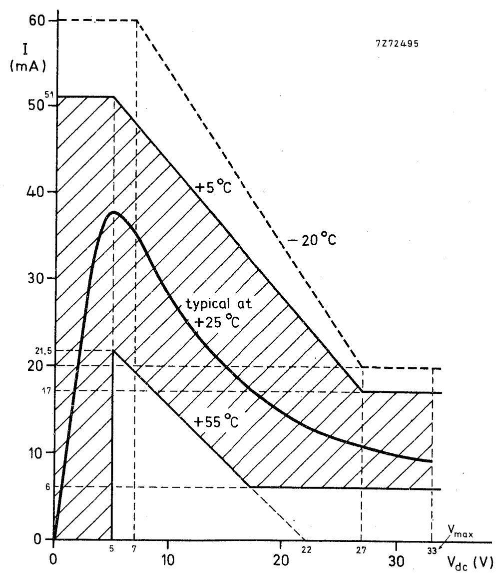


Fig. 7 Area of current/voltage characteristics.

PTC THERMISTORS
for motor start

QUICK REFERENCE DATA

Resistance value	
at T = +25 °C, 100 V pulsed	8,75 to 17,5 Ω
at T = +70 °C, 100 V pulsed	7,25 to 14,5 Ω
at T = +115 °C, 100 V pulsed	⩽ 30 Ω
Switch temperature	120 ± 10 °C
Maximum voltage (r.m.s.)	300 V
Operating ambient temperature range	
at zero power	−40 to +125 °C
at maximum voltage	0 to +80 °C

APPLICATION

Motor start.

DESCRIPTION

Disc thermistor with positive temperature coefficient; type 2322 678 93002 is a bare disc, type 2322 678 93001 is mounted in a plastic housing with stainless steel connectors.

MECHANICAL DATA

Outlines

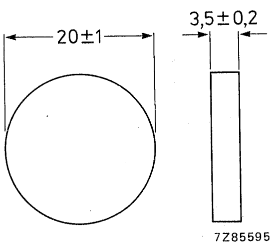


Fig. 1 Type 2322 678 93002.

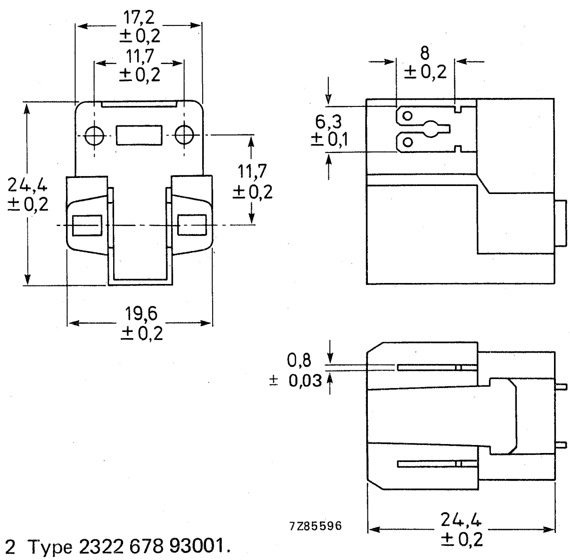


Fig. 2 Type 2322 678 93001.

	type	2322 678 93001	2322 678 93002	
Mass	≈	14,5	5,7	g
Mounting		plugged	clamped	
Robustness of terminations				
Tensile strength				
male		60 N	–	
female		55 N	–	
Impact				
Free fall		1000	200	mm
Inflammability		self-extinguishing	uninflammable	

PACKAGING

Type 2322 678 93001: 100 thermistors on preformed polysterene sheets.
Type 2322 678 93002: 100 thermistors in a cardboard box.

ELECTRICAL DATA

Resistance*		
at +25 °C, 100 V pulsed		8,75 to 17,5 Ω
at +70 °C, 100 V pulsed		7,25 to 14,5 Ω
at +115 °C, 100 V pulsed		⩽ 30 Ω
Switch temperature		120 ± 10 °C
Maximum voltage (r.m.s.) with series resistor of 33 Ω		300 V
Maximum static voltage (r.m.s.) at 25 °C, with a series resistor of 1000 Ω		455 V
Maximum residual current (r.m.s.), after 5 min at +80 °C, at 300 V (r.m.s.)		9,5 mA
Maximum inrush current (r.m.s.) with a minimum series resistor of 27 Ω, from 0 to + 80 °C		8 A
Minimum inrush current (r.m.s.) after 120 ms at + 80 °C at 242 V (r.m.s.) with a series resistor of 27 Ω		5,7 A
Heat capacity	≈	5 J/K
Thermal time constant by cooling (τ) (2322 678 93001)	≈	285 s
Dissipation factor at max. voltage (2322 678 93001)	≈	17,4 mW/K
Operating ambient temperature range		
at zero power		−40 to +125 °C
at maximum voltage		0 to +80 °C

* Measured without internal heating.

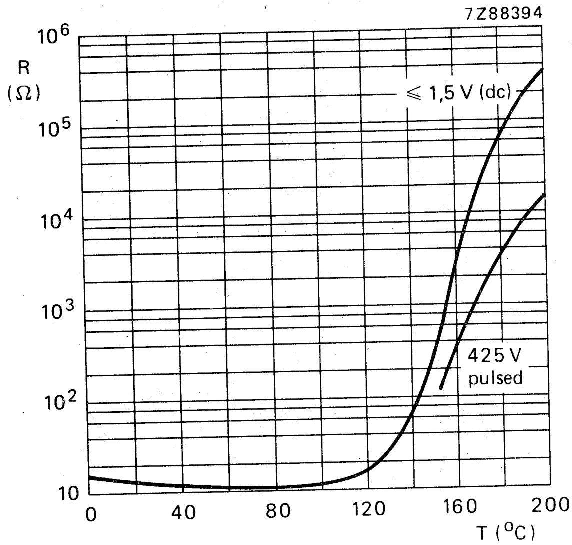


Fig. 3 Typical resistance/temperature characteristics.

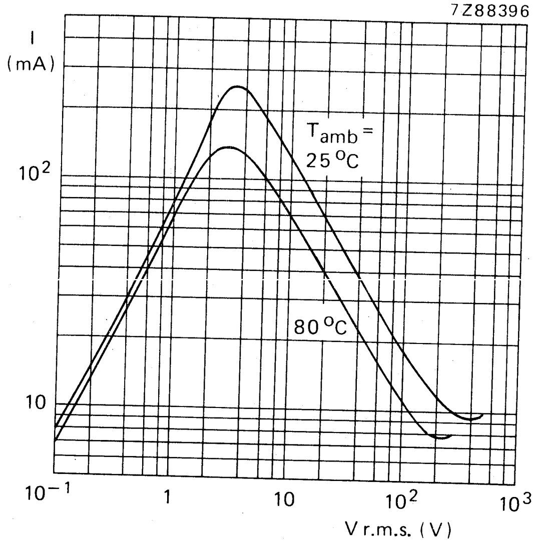


Fig. 4 Typical voltage/current characteristics; type 2322 678 93001.

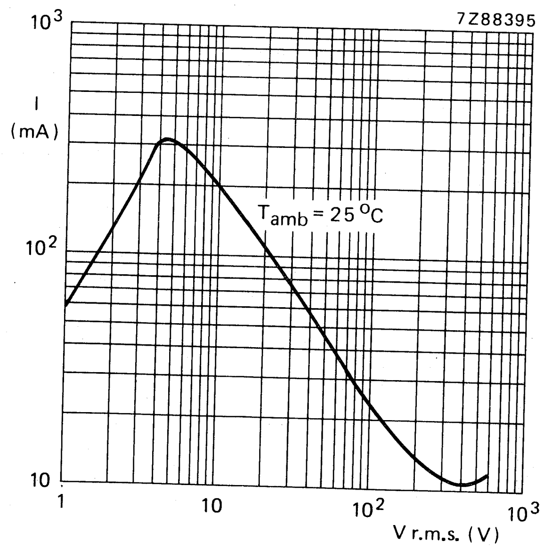


Fig. 5 Typical voltage/current characteristic, type 2322 678 93002.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 220 V	500 W
Operating power at 220 V after 20 min	
Time to reach + 180 °C at 220 V	≈ 4 min
Operating temperature range at zero power and at maximum voltage	−25 to + 60 °C

APPLICATION

Designed for applications that require high initial dissipation followed by moderate continuous dissipation, such as hot melt glue guns.

DESCRIPTION

Double insulated heating element consisting of a PTC thermistor moulded in a silicone rubber tube with two insulated copper wires which are partly covered by a silicone rubber sleeve.

MECHANICAL DATA

Outlines

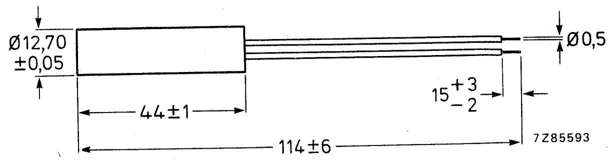


Fig. 1.

Marking	Connecting leads: red (twice)
Mounting	In any position by soldering or clamping
Robustness of terminations	
Tensile strength	20 N
Bending	5 N
Torsion	3 rotations of 360°
Soldering	
Solderability	max. 240 °C, max. 6 s
Impact	
Free fall	1830 mm

ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 °C.

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 220 V	500 W
Operating power at 220 V, after 20 min	
Time to reach + 180 °C at 220 V	≈ 4 min
Temperature on standard test mounting after 20 min at 220 V	220 ± 10 °C
Operating temperature range	
at zero power	−25 to + 60 °C
at maximum voltage	0 to + 60 °C

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 220 V	500 W
Operating power at 220 V after 20 min.	17 W ± 20%
Time to reach + 130 °C at 220 V	max. 7 min.
Ambient temperature range at zero power and at maximum voltage	−25 to +60 °C

APPLICATION

Designed for applications that require high initial dissipation followed by moderate continuous dissipation, such as hair curling tongs.

DESCRIPTION

Double insulated heating element consisting of a PTC thermistor moulded in a silicone rubber tube and two insulated copper wires which are partly covered by a silicone rubber sleeve.

MECHANICAL DATA

Dimensions in mm

Outlines

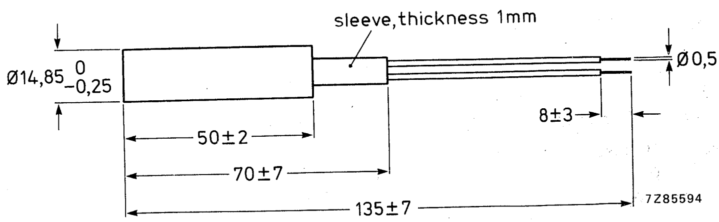


Fig. 1.

Marking	None
Mass	28 g approximately
Mounting	In any position by soldering or clamping
Robustness of terminations	
Tensile strength	20 N
Bending	5 N
Torsion	3 rotations of 360°
Soldering	
Solderability	max. 240 °C, max. 6 s
Impact	
Free fall	1000 mm

ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 °C

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 220 V (r.m.s.)	500 W
Operating power at 280 V (r.m.s.), after 20 min.	17 W ± 20%
Time to reach + 130 °C at 220 V	max. 7 min.
Temperature on standard test mounting after 20 min.	
at 120 V (r.m.s.)	≈ 177 °C
at 220 V (r.m.s.)	+ 185 ± 8 °C
Dielectric withstanding voltage (r.m.s.) between terminals and an aluminium tube acting as outer electrode *	min. 6 kV
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 5 kV
Insulation resistance between terminals and an aluminium tube acting as outer electrode, at 500 V (d.c.)	min. 10 MΩ
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 10 MΩ
Operating temperature range at zero power and at maximum voltage	−25 to +60 °C

* The heating element contains 2 silicone rubber tubes. The inner tube has a min. dielectric withstanding voltage of 1,5 kV, the outer one (min. wall thickness 1 mm) of 2,5 kV. The test voltage is a voltage increasing at a rate of 500 V/s, the maximum voltage is applied for 1 min.

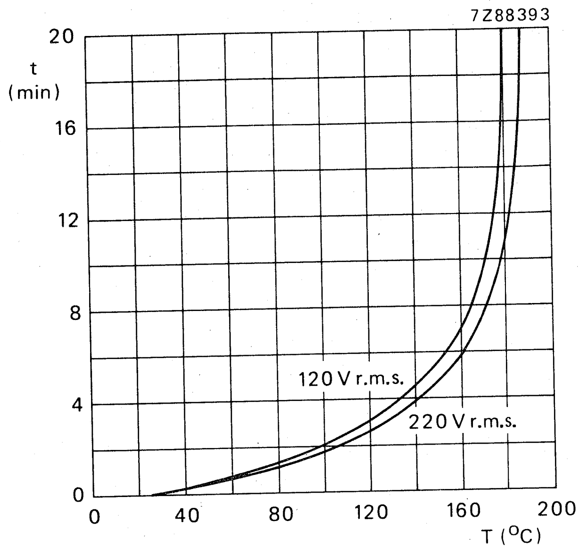


Fig. 2 Typical temperature/time stabilization characteristics.
Measured in standard test mounting.
$T_{amb} = +23\ ^{o}C$.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 220 V	500 W
Operating power at 220 V after 20 min	15 W ± 20%
Time to reach + 130 °C at 220 V	max. 7 min
Ambient temperature range at zero power and at maximum voltage	−25 to + 60 °C

APPLICATION

Designed for applications that require high initial dissipation followed by moderate continuous dissipation, such as hair curling tongs.

DESCRIPTION

Double insulated heating element composed of a PTC thermistor moulded in a silicone rubber tube and two insulated solid copper wires which are partly covered by a silicone rubber sleeve.

MECHANICAL DATA

Outlines

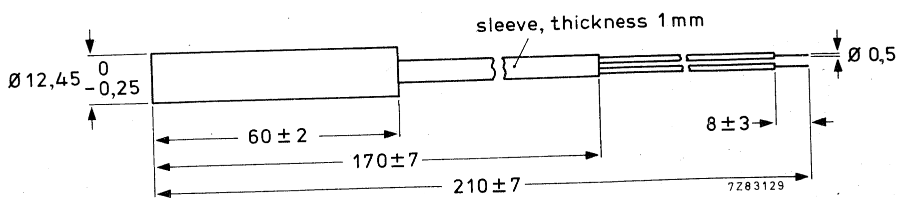


Fig. 1.

Making

PHILIPS, 2322 680 90047, 100-240 V, 15 W and batch no. on the body.

Mass	25 g approximately
Mounting	In any position by soldering or clamping
Robustness of terminations	
Tensile strength	20 N
Bending	5 N
Torsion	3 rotations of 360°
Soldering	
Solderability	max. 240 °C, max. 6 s
Impact	
Free fall	1830 mm

ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 °C.

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 220 V	500 W
Operating power at 220 V, after 20 min	15 W ± 20%
Time to reach + 130 °C at 220 V	max. 7 min
Temperature on standard test mounting after 20 min	
at 120 V	min. 170 °C
at 220 V	+ 185 ± 8 °C
Dielectric withstanding voltage (r.m.s.) between terminals and an aluminium tube acting as outer electrode *	min. 6 kV
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 5 kV
Insulation resistance between terminals and an aluminium tube acting as outer electrode	min. 10 MΩ
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 10 MΩ
Ambient temperature range at zero power and at maximum voltage	−25 to + 60 °C

* The heating element contains 2 silicone rubber tubes. The inner tube has a min. dielectric withstanding voltage of 1,5 kV, the outer one (min. wall thickness 1 mm) of 2,5 kV. The test voltage is a voltage increasing at a rate of 500 V/s, the maximum voltage is applied for 1 min.

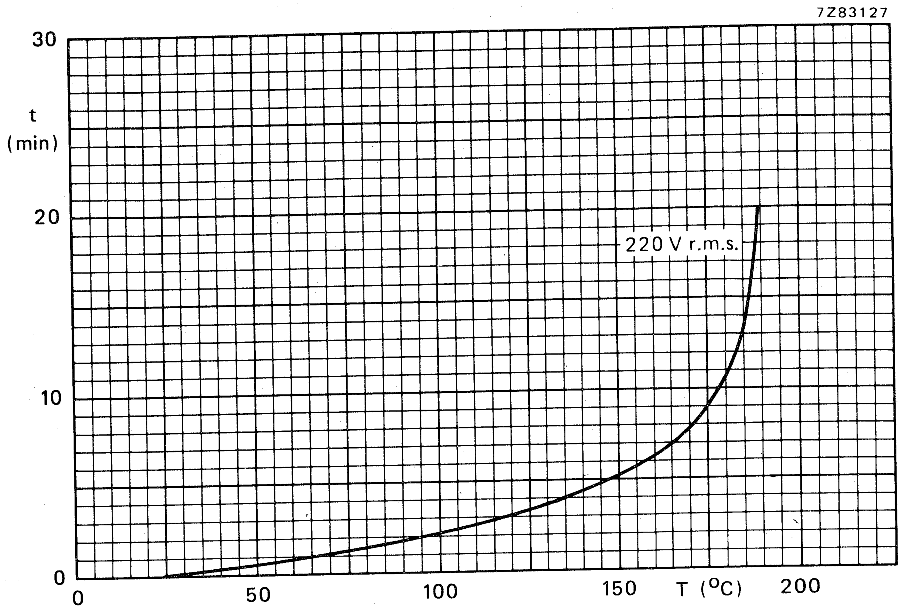


Fig. 2 Typical temperature versus time characteristics. Measured in standard test mounting. T_{amb} = +23 °C.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 110 V (r.m.s.)	200 W
Operating power at 110 V after 20 min	15 W ± 20%
Time to reach + 130 °C at 110 V	max. 7 min
Ambient temperature range at zero power and at maximum voltage	−25 to +60 °C

APPLICATION

Designed for applications that require high initial dissipation followed by moderate continuous dissipation, such as hair curling tongs.

DESCRIPTION

Double insulated heating element composed of a PTC thermistor moulded in a silicone rubber tube and two insulated solid copper wires which are partly covered by a silicone rubber sleeve.

MECHANICAL DATA

Outlines

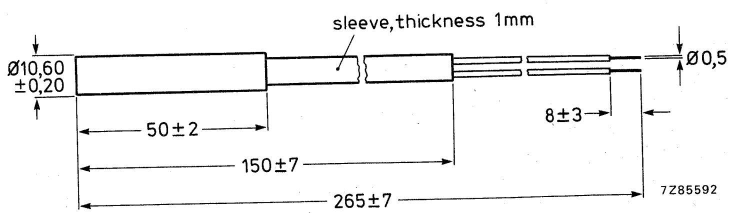


Fig. 1.

Marking	Connecting leads: one orange and one blue.
Mass	28 g approximately
Mounting	In any position by soldering or clamping
Robustness of terminations	
Tensile strength	20 N
Bending	5 N
Torsion	3 rotations of 360°
Soldering	
Solderability	max. 240 °C, max. 6 s
Impact	
Free fall	1000 mm

ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 °C

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 110 V	200 W
Operating power at 110 V (r.m.s.), after 20 min	15 W ± 20%
Time to reach + 130 °C at 110 V	max. 7 min
Temperature on standard test mounting after 20 min at 110 V (r.m.s.)	+ 175 ± 8 °C
Dielectric withstanding voltage (r.m.s.) between terminals and an aluminium tube acting as outer electrode*	min. 4 kV
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 4 kV
Insulation resistance between terminals and an aluminium tube acting as outer electrode at 500 V (d.c.)	min. 10 MΩ
after 48 ± 0,5 h at 93 ± 2% R.H. and 32 ± 1 °C, measured inside test chamber	min. 10 MΩ
Operating temperature range at zero power and at maximum voltage	–25 to + 60 °C

* The test voltage is a voltage increasing at a rate of 500 V/s, the maximum voltage is applied for 1 min.

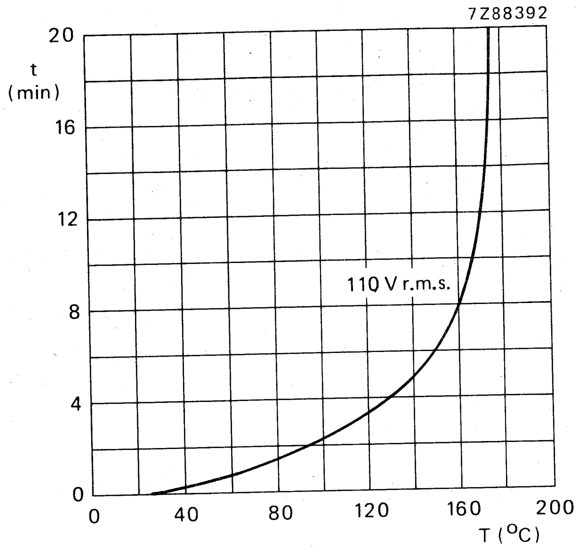


Fig. 2 Typical temperature versus time stabilization characteristic.
Measured in standard test mounting.
T_{amb} = +23 °C.

PTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance at T_{amb} = +25 °C	see Tables 2 and 3
Maximum resistance at T_{amb} = +115 °C	see Tables 2 and 3
Switch temperature	+115 °C
Maximum voltage (d.c. or r.m.s.)	60 V (Table 2) or 245 V (Table 3)
Dissipation factor	see Tables 2 and 3
Ambient temperature range at maximum voltage	0 to +55 °C

APPLICATION

For protection of electric and electronic components against overload, e.g. motors, transformers, light dimmers, etc.

A selection from our range of PTC thermistors which are suitable for this purpose is given.

DESCRIPTION

These thermistors have a positive temperature coefficient. They consist of a disc with two tinned copper or brass wires. The thermistors are neither lacquered nor insulated.

MECHANICAL DATA

Outlines	see Figs 1 and 2
Marking	none
Mass	see Table 1
Mounting	in any position by soldering
Robustness of terminations	
Tensile strength	
Thermistors of Fig. 1	20 N
Thermistors of Fig. 2	10 N
Bending	
Thermistors of Fig. 1	10 N
Thermistors of Fig. 2	5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 260 °C, max. 11 s
Impact	
Free fall	1 m
Inflammability	uninflammable

Dimensions in mm

Table 1 Outlines

type	D ± 5%	L ± 5	C max.	d	mass approx. g
2322 661 91019	8	54	7	0,8	0,8
2322 661 93001	8	54	13	0,8	1,3
2322 662 91004	10	55	11	0,8	0,9
2322 662 91006	12	56	11	0,8	1,1
2322 662 93015	10	55	13	0,8	1,6
2322 662 93017	12	56	13	0,8	2,1
2322 663 91002	16	58	11	0,8	1,7
2322 663 93006	16	58	13	0,8	3,3
2322 664 91002	20	60	11	0,8	2,2
2322 664 93014	20	60	13	0,8	4,8

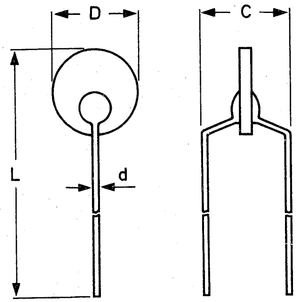


Fig. 1.

type	D ± 5%	L ± 5	C max.	d	mass approx. g
2322 660 91017	4,5	52,5	4	0,5	0,4
2322 660 93006	4,5	52,5	5,5	0,5	0,5
2322 660 93011	4,5	52,5	5,5	0,5	0,5
2322 660 93012	4,5	52,5	5,5	0,5	0,5
2322 660 93013	4,5	52,5	5,5	0,5	0,5
2322 660 93014	4,5	52,5	5,5	0,5	0,5
2322 661 91021	8	54	4	0,5	0,6
2322 661 93002	8	54	5,5	0,5	1,0
2322 662 91005	10	55	4	0,5	0,7
2322 662 91007	12	56	4	0,5	0,9
2322 662 93016	10	55	5,5	0,5	1,4
2322 662 93018	12	56	5,5	0,5	1,8
2322 663 91003	16	58	4	0,5	1,4
2322 663 93007	16	58	5,5	0,5	3,0
2322 664 91003	20	60	4	0,5	1,9
2322 664 93015	20	60	5,5	0,5	4,6
2322 672 91016	3	51,5	4	0,5	0,25
2322 672 93003	3	51,5	5,5	0,5	0,3

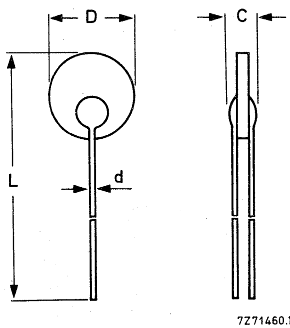


Fig. 2.

More extended information on thermistors for overload protection for the ranges 265 V and 35 V is available separately.

ELECTRICAL DATA

Table 2 Low-voltage PTC thermistors: V_{max} at + 55 °C = 60 V; T_s = + 115 °C

R_{25} Ω ± 25%	R_{115} Ω max.	$I_{stat\ peak}$ A at 25 °C	$I_{stat\ peak}$ A at 55 °C	I_{max} A at 0 °C and 60 V	t_{resp} s at 25 °C and I_{max}	D mW/K	I_{res} mA	R_s Ω min.	catalogue number
1,65	3,5	0,85	0,64	7,5	3	20	63	6,2	2322 664 91002
1,65	3,5	0,75	0,57	6,5	3	15	53	7,5	664 91003
2,3	5	0,63	0,47	5,25	3	15	51	9,1	663 91002
2,3	5	0,50	0,37	4,5	3	10	36	11	663 91003
3,7	7	0,44	0,33	3,5	3	12	39	13,5	662 91006
3,7	7	0,35	0,26	2,75	3	7,5	29	18	662 91007
5,6	12	0,34	0,25	2,7	3	11	31	16	662 91004
5,6	12	0,26	0,195	2	3	6,5	22	24	662 91005
9,4	20	0,25	0,19	1,9	3	10	28	22	661 91019
9,4	20	0,18	0,135	1,3	3	5	16	36	661 91021
25	55	0,09	0,068	0,65	3	4	12,5	68	660 91017
55	120	0,059	0,044	0,4	3	3,5	10,5	95	672 91016

Table 3 High-voltage PTC thermistors: V_{max} at + 55 °C = 245 V; T_s = + 115 °C

R_{25} Ω ± 25%	R_{115} Ω max.	$I_{stat\ peak}$ A at 25 °C	$I_{stat\ peak}$ A at 55 °C	I_{max} A at 0 °C and 245 V	t_{resp} s at 25 °C and I_{max}	D mW/K	I_{res} mA	R_s Ω min.	catalogue number
3,7	8	0,55	0,41	4,9	6	20	18	47	2322 664 93014
3,7	8	0,5	0,38	4,5	6	15,5	17	51	664 93015
6	15	0,4	0,3	3,0	6	16	16	75	663 93006
6	15	0,35	0,25	3,5	6	11	13	91	663 93007
10	25	0,27	0,2	1,8	7	12,5	14	120	662 93017
10	25	0,235	0,175	1,5	7	9	10	150	662 93018
15	40	0,215	0,162	1,3	7	11	14	180	662 93015
15	40	0,162	0,120	1	7	6,5	8,5	220	662 93016
25	60	0,150	0,115	0,9	7	10	11,5	240	661 93001
25	60	0,115	0,087	0,7	7	5,5	7	330	661 93002
70	160	0,059	0,045	0,25	8	4	5,5	910	660 93006
120	400	0,045	0,034	0,19	8	7	5	1100	660 93011
150	400	0,036	0,027	0,1	8	4	4,5	2200	672 93003
600	3000	0,020	0,015	0,085	8	7	4,5	2200	660 93012
1200	4000	0,014	0,011	0,060	8	7	4,5	2700	660 93013
1500	5000	0,013	0,010	0,055	8	7	4,5	3000	660 93014

Definitions of terms used in Tables 2 and 3.

V_{max}	max. d.c. or a.c. voltage at + 55 °C.
$I_{stat\ peak}$	max. stationary operating current.
I_{max}	max. current at T_{amb} = 0 °C.
t_{resp}	time taken for the thermistor to reach the switching temperature.
D	dissipation factor measured in still air.
I_{res}	residual current at V_{max}.

HUMIDITY SENSOR E

HUMIDITY SENSOR

QUICK REFERENCE DATA

Humidity range	10 to 90% R.H.
Capacitance at +25 °C, 43% R.H. and 100 kHz	122 pF ± 15%
Sensitivity between 33 and 43% R.H.	0,4 ± 0,05 pF/% R.H.
Frequency range	1 kHz to 1 MHz
Maximum a.c. or d.c. voltage	15 V
Storage humidity range	0 to 100% R.H.
Ambient temperature range	
Operating	0 to +85 °C
Storage	−25 to +85 °C

APPLICATION

For humidity measurements in e.g. electronic hygrometers for domestic use, laundry dryers with automatic switch-off, self-regulating air humidifiers.

DESCRIPTION

This capacitive atmospheric humidity sensor consists of a non-conductive foil, which is covered on both sides with a layer of gold. The dielectric constant of the foil changes as a function of the relative humidity of the ambient atmosphere and, accordingly, the capacitance value of the sensor is a measure for relative humidity. The foil is clamped between contact springs and assembled in a plastic housing. It is provided with two connecting pins fitting printed-wiring boards with a grid pitch of 2,54 mm, provision is also made for fastening with 3 mm bolts. The characteristics are not affected by an incidental condensation of water on the sensor foil. It should not be exposed to acetone vapour.

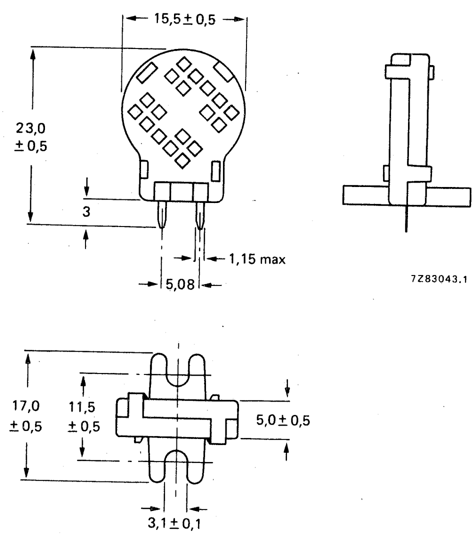


Fig. 1 Dimensions in mm.

MECHANICAL DATA

Outlines

See Fig. 1.

Marking	PHILIPS H1
Mass	1,3 g approximately

Mounting

The item can be soldered directly onto a printed-wiring board or can be fastened with 3 mm bolts.

Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s
Robustness of terminations	
Tensile strength	10 N
Impact	
Free fall	1 m
Inflammability	uninflammable

ELECTRICAL DATA

Humidity range	10 to 90% R.H.
Capacitance at +25 °C. 43% R.H., 100 kHz	122 pF ± 15%
Tan δ at +25 °C and 100 kHz	$<$ 3,5%
Sensitivity between 33 and 43% R.H.	0,4 ± 0,05 pF/% R.H.
Frequency range	1 kHz to 1 MHz
Temperature dependence	0,1% R.H./K
Response time (to 90% of indicated R.H. change at +25 °C, in circulating air)	
between 10 and 43% R.H.	$<$ 3 min.
between 43 and 90% R.H.	$<$ 5 min.
Hysteresis (for R.H. excursion of 10 to 90 to 10%)	3% approximately
Maximum a.c. or d.c. voltage	15 V
Storage humidity range	0 to 100% R.H.
Ambient temperature range	
Operating	0 to +85 °C
Storage	−25 to +85 °C

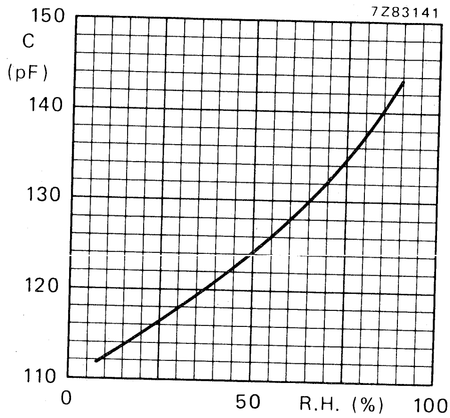


Fig. 2 Typical capacitance/relative humidity characteristic.

QUALITY LEVEL

Sampling and data evaluation for quality level according to MIL-STD-105D.

A.Q.L. 0,25% – Inoperatives
A.Q.L. 1% – Electrical
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