PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Components and materials

Part 11 December 1979

Voltage dependent resistors

Light dependent resistors

Negative temperature coefficient thermistors

Positive temperature coefficient thermistors

COMPONENTS AND MATERIALS

PART 11 - DECEMBER 1979

NON-LINEAR RESISTORS

VOLTAGE DEPENDENT RESISTORS (VDR)

LIGHT DEPENDENT RESISTORS (LDR)

NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC)

HUMIDITY SENSOR

DATA HANDBOOK SYSTEM

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

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

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

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

Part 1a	December 1975	ET1a 12-75	**Transmitting tubes for communication, tubes for r.f. heating** Types PE05/25 to TBW15/25
Part 1b	August 1977	ET1b 08-77	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2a	November 1977	ET2a 11-77	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 2b	May 1978	ET2b 05-78	**Microwave semiconductors and components** Gunn, Impatt and noise diodes, mixer and detector diodes, backward diodes, varactor diodes, Gunn oscillators, sub-assemblies, circulators and isolators
Part 3	January 1975	ET3 01-75	**Special Quality tubes, miscellaneous devices**
Part 4	March 1975	ET4 03-75	**Receiving tubes**
Part 5a	October 1979	ET5a 10-79	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	December 1978	ET5b 12-78	**Camera tubes and accessories, image intensifiers**
Part 6	January 1977	ET6 01-77	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	March 1977	ET7a 03-77	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	May 1979	ET7b 05-79	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	July 1979	ET8 07-79	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, monitor tubes, components for colour television, components for black and white television.
Part 9	March 1978	ET9 03-78	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**August 1978**	**SC1a 08-78**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**December 1979**	**SC1b 12-79**	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors***
Part 2	**June 1979**	**SC2 06-79**	**Low-frequency power transistors**
Part 3	**January 1978**	**SC3 01-78**	**High-frequency, switching and field-effect transistors**
Part 4a	**December 1978**	**SC4a 12-78**	**Transmitting transistors and modules**
Part 4b	**September 1978**	**SC4b 09-78**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, photocouplers, infrared sensitive devices, photoconductive devices
Part 4c	**July 1978**	**SC4c 07-78**	**Discrete semiconductors for hybrid thick and thin-film circuits**
Part 5a	**November 1978**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Part 6b	**August 1979**	**SC6b 08-79**	**ICs for digital systems in radio and television receivers**
Signetics integrated circuits 1978			Bipolar and MOS memories Bipolar and MOS microprocessors Analogue circuits Logic - TTL

* Low-frequency general purpose transistors will be transferred to SC3 later in 1979. The old book SC2 11-77 should be kept until then.

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	**July 1979**	**CM1 07-79**	**Assemblies for industrial use** PLC modules, high noise immunity logic FZ/30-series, NORbits 60-series, 61-series, 90-series, input devices, hybrid integrated circuits, peripheral devices
Part 2b	**February 1978**	**CM2b 02-78**	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3a	**September 1978**	**CM3a 09-78**	**FM tuners, television tuners, surface acoustic wave filters**
Part 3b	**October 1978**	**CM3b 10-78**	**Loudspeakers**
Part 4a	**November 1978**	**CM4a 11-78**	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	**February 1979**	**CM4b 02-79**	**Piezoelectric ceramics, permanent magnet materials**
Part 6	**April 1977**	**CM6 04-77**	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	**September 1971**	**CM7 09-71**	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 7a	**January 1979**	**CM7a 01-79**	**Assemblies** Circuit blocks 40-series and CSA70 (L), counter modules 50-series, input/output devices
Part 8	**June 1979**	**CM8 06-79**	**Variable mains transformers**
Part 9	**August 1979**	**CM9 08-79**	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators
Part 10	**April 1978**	**CM10 04-78**	**Connectors**
Part 11	**December 1979**	**CM11 12-79**	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
Part 12	**November 1979**	**CM12 11-79**	**Variable resistors and test switches**
Part 13	**December 1979**	**CM13 12-79**	**Fixed resistors**

VOLTAGE DEPENDENT RESISTORS (VDR)

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How to measure VDRs	13
Applications	15
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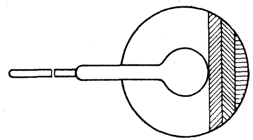
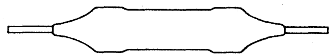
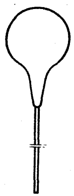
SURVEY

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 03... 2322 564 90...
SMALL DISC 					
silicon carbide	6 to 18	1	0,1		2322 565 9000.
titanium oxide	2,7 to 68	1	0,25	max. 0,20 to 0,28	2322 581 03...
zinc oxide	48	0,05	0,1	max. 0,11	2322 592 90004
zinc oxide	60 to 460		0,1 0,3		2322 592 7.... 2322 594 7....

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.

* Philips patented.

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.

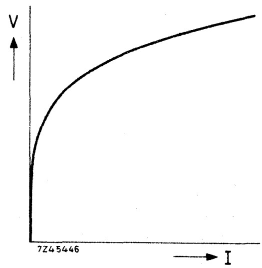


Fig. 1 Shape of the voltage/current characteristic of a VDR when plotted on a linear scale.

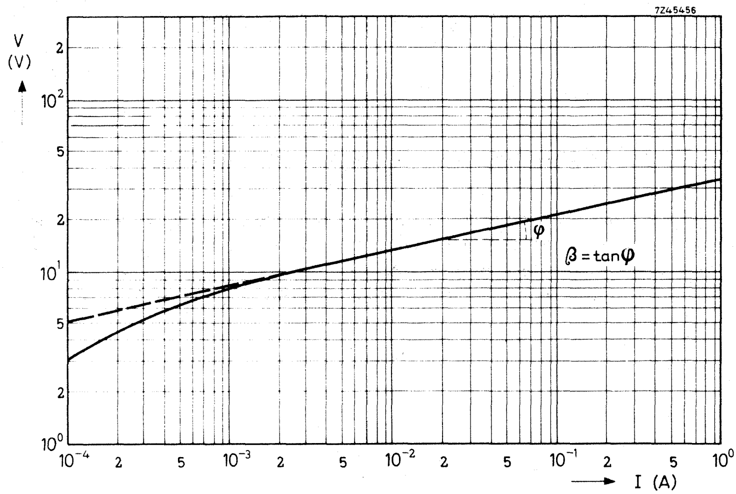


Fig. 2 Voltage/current characteristic of a VDR plotted on a logarithmic scale.

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:

$$I = KV^{\alpha} \quad (2)$$

in which:

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

and

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

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 range between 0,02 and 0,40. 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:

$$V = CI^{\beta}. \qquad (1)$$

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:

$$nV = C'.I^{\beta}. \qquad (4)$$

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

$$C' = nC, \qquad (5)$$

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:

$$V = CI^{\beta}. \qquad (1)$$

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:

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

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

$$C'' = \frac{C}{n^{\beta}}. \qquad (7)$$

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. β = 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 $I = KV^{\alpha}$:

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

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:

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

When the coefficient α = 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.

ALTERNATING CURRENT

If a sinusoidal voltage is applied to a VDR, the non-linear voltage current characteristic will cause the current to be non-sinusoidal, but the latter will, for reasons of symmetry, include only odd harmonics. Figure 3 shows an oscillogram of this phenomenon. If a VDR is carrying a sinusoidal current, the voltage across the VDR will be non-sinusoidal.

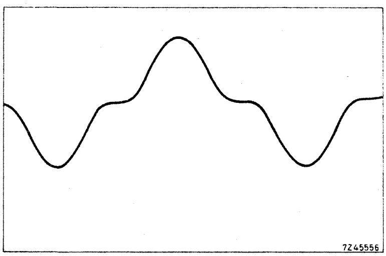


Fig. 3 Current as a function of time when a sinusoidal voltage is applied to a VDR.

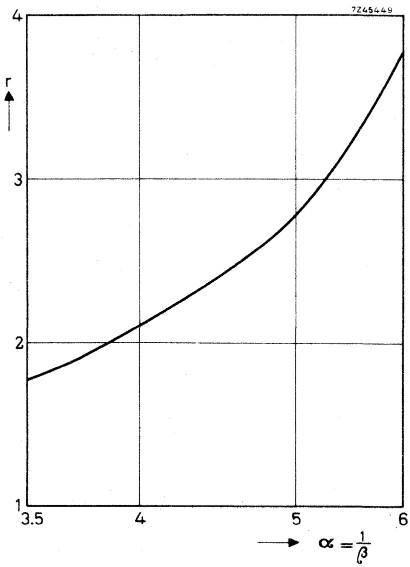
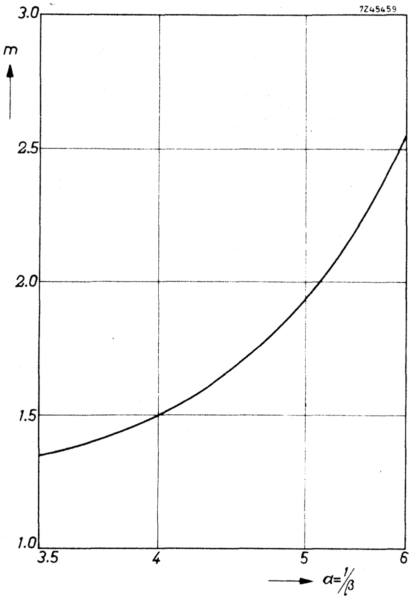


Fig. 4 Relation between the currents caused by a d.c. voltage V and an a.c. voltage V_{rms} = V.

$r = I_{rms}/I$



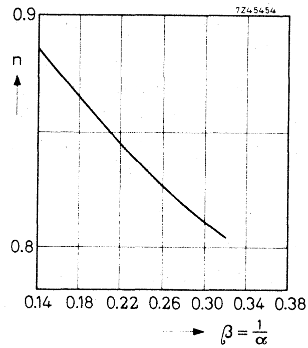


Fig. 6 Relation between the voltages across a VDR carrying a direct current I or a sinusoidal alternating current I_{rms} = I.
n = V_{rms}/V.

Fig. 5 Relation between the mean values of the currents caused by a d.c. voltage V and an a.c. voltage V_{rms} = V.
m = I_m/I

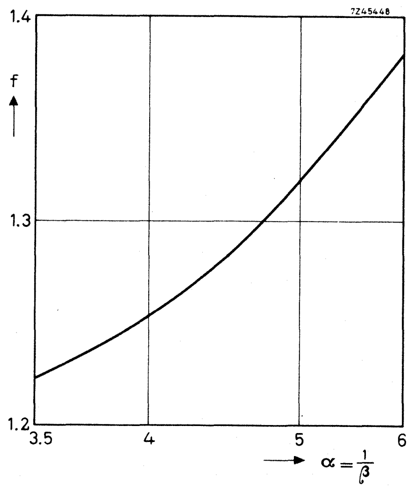


Fig. 7 Error in the reading of I_{rms} on a moving-coil ammeter with rectifiers.

When measuring the alternating current in a VDR erroneous readings will be obtained if a moving-coil instrument, operating with rectifiers, is used. Normally these instruments are calibrated in r.m.s. values and are correct only for sinusoidal alternating voltages or currents. Actually they indicate the mean values of these magnitudes. When a current according to Fig. 3 has to be measured with an assembly of this kind, the deflection of the instrument will be proportional to the mean value of the current. For obtaining the r.m.s. value the reading must be multiplied by a factor f which is given in Fig. 7 as a function of α.

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.

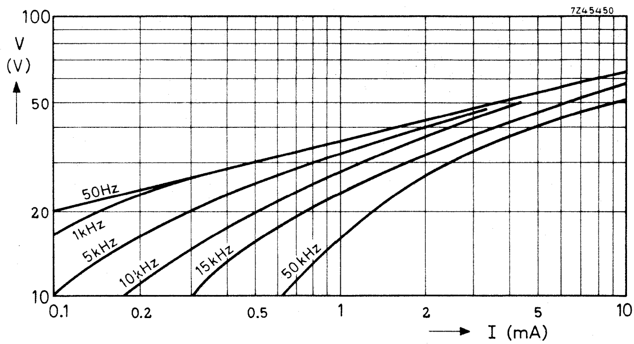


Fig. 8 Voltage/current relation for different frequencies.

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 68 V to 415 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 0,035. 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 1,08.

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 7.... and 2322 594 7.... .

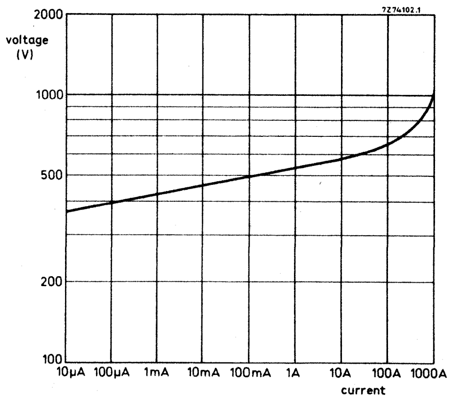


Fig. 9 Typical V/I characteristic of ZnO VDR 2322 594 72512 for 220 V mains supply.

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.

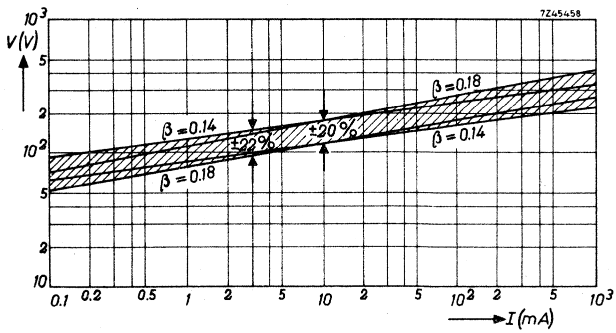


Fig. 10 Spread of voltage/current characteristic due to β-tolerance.

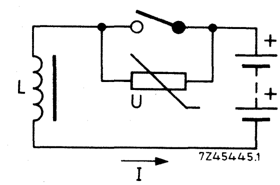
APPLICATIONS

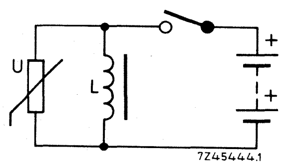
Some of the most important application principles are given in the following pages. Well known television applications are the VDR used as a rectifier of non-symmetrical pulses, and for stabilization against supply voltage variations and aging of components. The VDR is also used in TV sets across the 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 and 2322 594 series) are designed especially for the suppression of voltage transients.

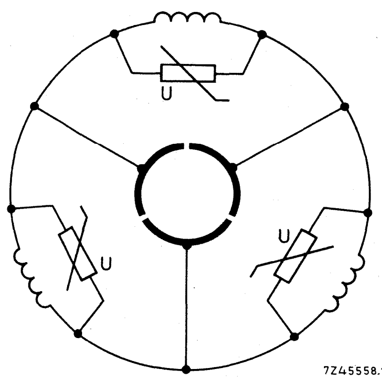




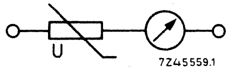
Protection of small battery motors

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

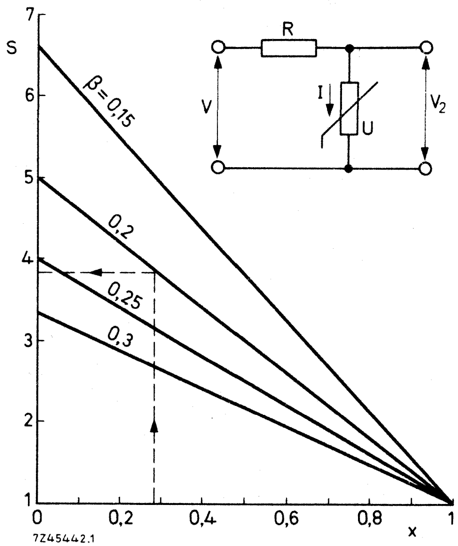


A VDR in series with a voltmeter or in parallel with a milliammeter enables part of the scale to be expanded for more accurate reading of measurements.

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

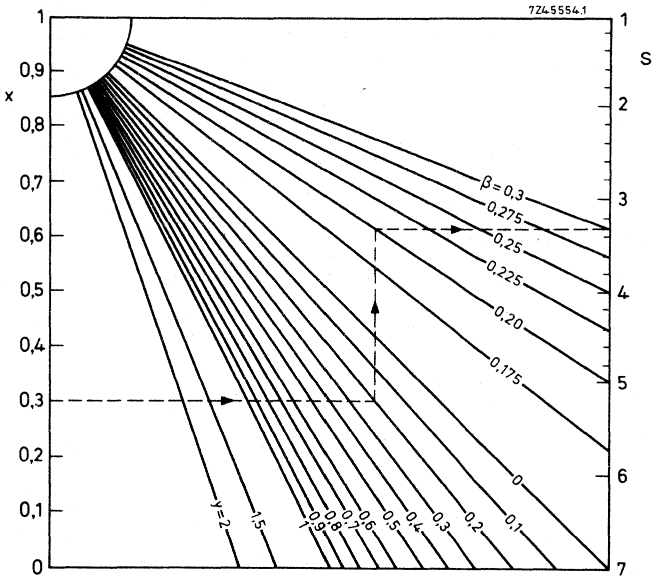
$$S = \frac{\Delta V/V}{\Delta V_2/V_2} = \frac{1}{\beta} - \frac{1-\beta}{\beta} \cdot x, \quad \text{where } x = V_2/V.$$

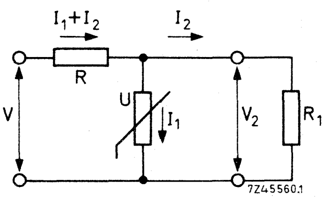


Stabilization of a voltage with load

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

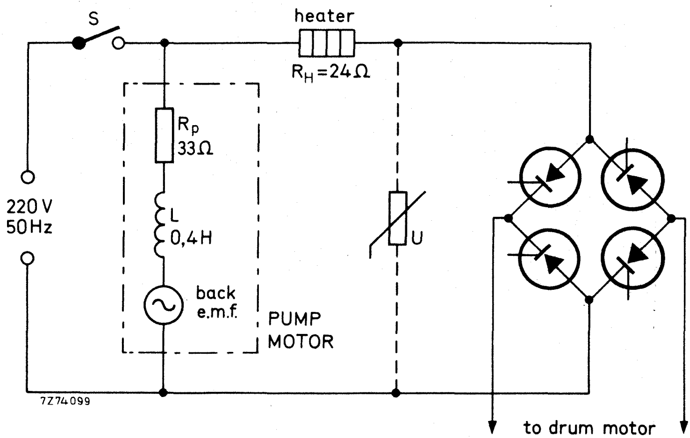
The nomogram makes S easy to find.





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 594 72512

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

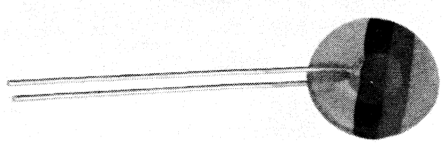
$$V = C_{max}\, I^{\beta} = 600 \text{ V}.$$

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

standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA d.c.	8 to 12 V
Voltages at I_{nom} = 10 mA d.c.	8 to 68 V
Voltages at I_{nom} = 1 mA d.c.	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	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

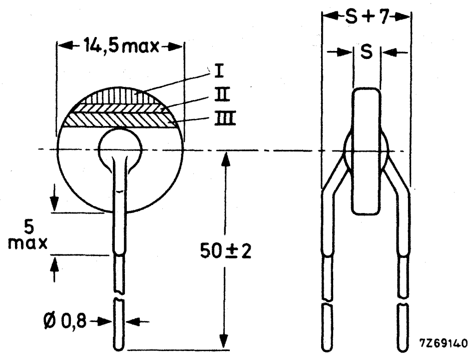


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

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

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig.1 (mm)	weight (g)	colour code 2)			catalogue number 1)
						I	II	III	
100	8	0.25-0.40	14	3	1,3	brown	brown	blue	2322 552 01161
100	10	0.25-0.40	18	3	1,3	brown	brown	grey	2322 552 01181
100	12	0.25-0.40	21	3	1,3	brown	red	black	2322 552 01201
10	8	0.25-0.40	25	3	1,3	red	brown	blue	2322 552 02161
10	10	0.25-0.40	32	3	1,4	red	brown	grey	2322 552 02181
10	12	0.25-0.40	40	3	1,4	red	red	black	2322 552 02201
10	15	0.25-0.40	48	3	1,4	red	red	red	2322 552 02221
10	18	0.21-0.35	57	3	1,45	red	red	yellow	2322 552 02241
10	22	0.21-0.35	60	3	1,45	red	red	blue	2322 552 02261
10	27	0.21-0.35	70	3	1,45	red	red	grey	2322 552 02281
10	33	0.18-0.25	85	3	1,45	red	orange	black	2322 552 02301
10	39	0.18-0.25	100	3	1,45	red	orange	red	2322 552 02321
10	47	0.18-0.25	130	5	1,45	red	orange	yellow	2322 552 02341
10	56	0.18-0.25	150	5	1,45	red	orange	blue	2322 552 02361
10	68	0.18-0.25	180	5	1,45	red	orange	grey	2322 552 02381
1	56	0.14-0.23	190	5	1,45	orange	orange	blue	2322 552 03361
1	68	0.14-0.23	230	5	1,45	orange	orange	grey	2322 552 03381
1	82	0.14-0.21	300	5	1,5	orange	yellow	black	2322 552 03401
1	100	0.14-0.21	350	5	1,6	orange	yellow	red	2322 552 03421
1	120	0.14-0.21	400	5	1,65	orange	yellow	yellow	2322 552 03441
1	150	0.14-0.21	500	5	1,75	orange	yellow	blue	2322 552 03461
1	180	0.14-0.21	600	5	1,9	orange	yellow	grey	2322 552 03481
1	220	0.14-0.21	750	5	2,15	orange	green	black	2322 552 03501
1	270	0.14-0.21	900	5	2,3	orange	green	red	2322 552 03521
1	330	0.14-0.21	1100	5	2,6	orange	green	yellow	2322 552 03541

1) For a voltage tolerance of $\pm 10\%$ the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	±20% [1]
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

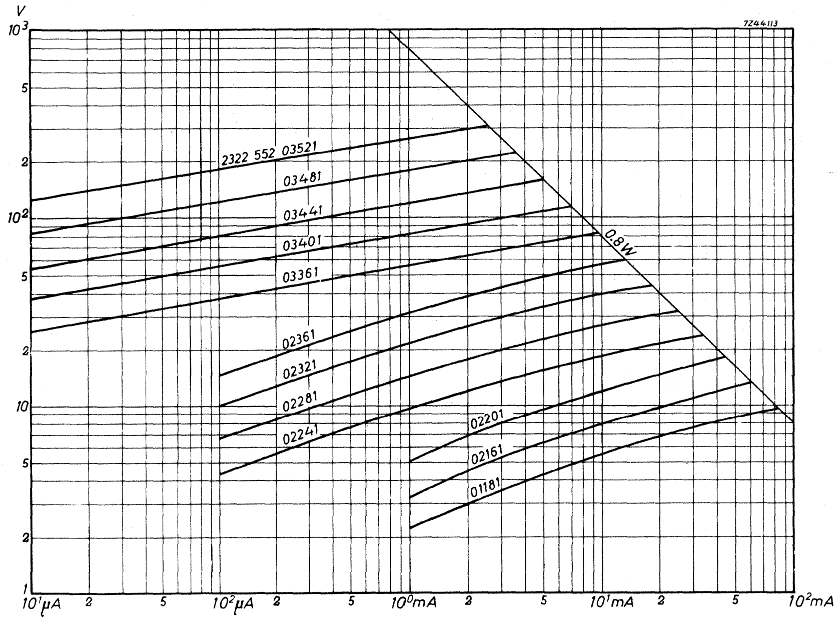


Fig. 2. Voltage/current characteristics

[1]) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	±3	±3
Storage at +25 °C	H	1000 h	±2	±3
Dry heat at +125 °C	B	1000 h	±3	±5
Thermal shock −25 to +125 °C	Na	5 cycles	±3	±5
Damp heat at +40 °C	Ca	1000 h	±3	±5
Dissipation in damp heat		336 h	±3.5	±7
Max. dissipation at T_{amb} = +25 °C		1000 h	±5	±10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at +230 ±10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat +230 ±10 °C	par 3.2.4	3 to 4 s	±2	±2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

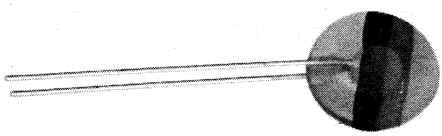
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA	8 to 15 V
Voltages at I_{nom} = 10 mA	10 to 82 V
Voltages at 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	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

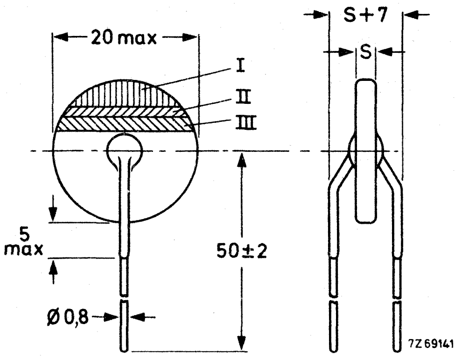


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

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

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig. 1 (mm)	weight (g)	colour code 2)			catalogue number 1)
						I	II	III	
100	8	0.25-0.40	14	3	1,7	brown	brown	blue	2322 553 01161
100	10	0.25-0.40	18	3	1,8	brown	brown	grey	2322 553 01181
100	12	0.25-0.40	21	3	1,9	brown	red	black	2322 553 01201
100	15	0.25-0.40	26	3	1,9	brown	red	red	2322 553 01221
10	10	0.25-0.40	32	3	1,9	red	brown	grey	2322 553 02181
10	12	0.25-0.40	40	3	2,0	red	red	black	2322 553 02201
10	15	0.25-0.40	48	3	2,0	red	red	red	2322 553 02221
10	18	0.21-0.35	57	3	2,0	red	red	yellow	2322 553 02241
10	22	0.21-0.35	60	3	2,1	red	red	blue	2322 553 02261
10	27	0.21-0.35	70	3	2,1	red	red	grey	2322 553 02281
10	33	0.18-0.25	85	3	2,1	red	orange	black	2322 553 02301
10	39	0.18-0.25	100	3	2,1	red	orange	red	2322 553 02321
10	47	0.18-0.25	130	5	2,1	red	orange	yellow	2322 553 02341
10	56	0.18-0.25	150	5	2,1	red	orange	blue	2322 553 02361
10	68	0.18-0.25	180	5	2,1	red	orange	grey	2322 553 02381
10	82	0.14-0.23	190	5	2,1	red	yellow	black	2322 553 02401
1	68	0.14-0.23	230	5	2,1	orange	orange	grey	2322 553 03381
1	82	0.14-0.21	300	5	2,1	orange	yellow	black	2322 553 03401
1	100	0.14-0.21	350	5	2,3	orange	yellow	red	2322 553 03421
1	120	0.14-0.21	400	5	2,4	orange	yellow	yellow	2322 553 03441
1	150	0.14-0.21	500	5	2,6	orange	yellow	blue	2322 553 03461
1	180	0.14-0.21	600	5	2,9	orange	yellow	grey	2322 553 03481
1	220	0.14-0.21	750	5	3,3	orange	green	black	2322 553 03501
1	270	0.14-0.21	900	5	3,7	orange	green	red	2322 553 03521
1	330	0.14-0.21	1100	5	4,2	orange	green	yellow	2322 553 03541

1) For a voltage tolerance of ± 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

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

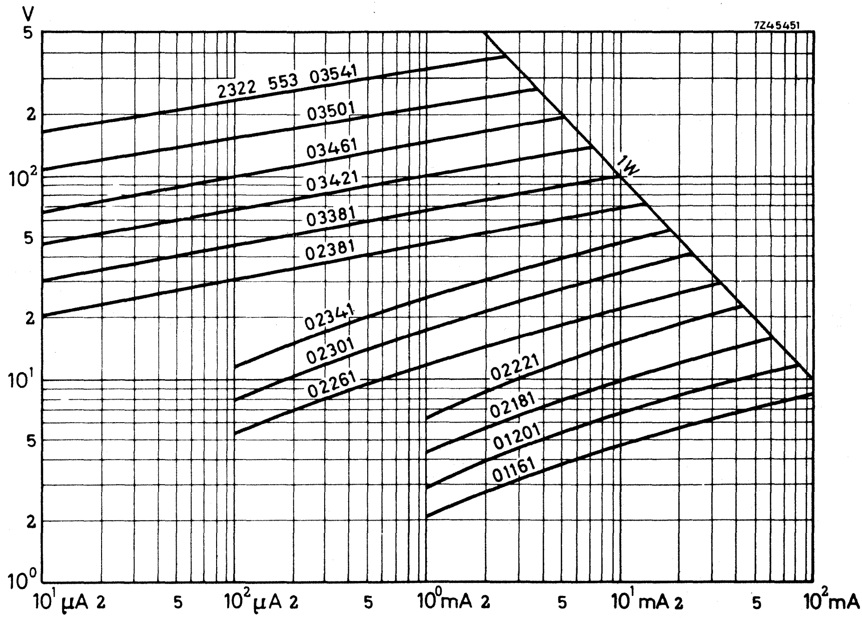


Fig. 2. Voltage/current characteristics

1) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

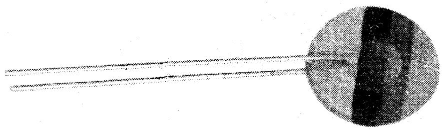
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA	8 to 18 V
Voltages at I_{nom} = 10 mA	10 to 82 V
Voltages at 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	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

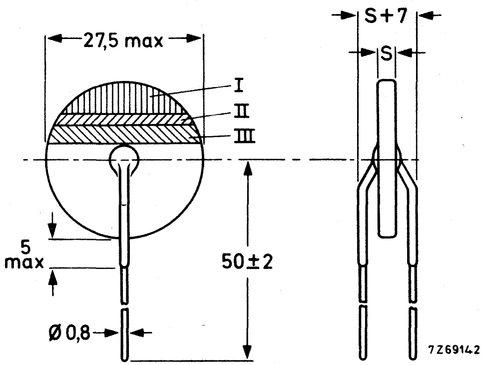


Fig.1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig.1 and Table 1.

Weight

See Table 1

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

d.c. current Inom (mA)	voltage at Inom (V)	β	C approx.	S max. Fig.1 (mm)	weight (g)	colour code [2]			catalogue number [1]
						I	II	III	
100	8	0.25-0.40	14	3	2,9	brown	brown	blue	2322 554 01161
100	10	0.25-0.40	18	3	2,95	brown	brown	grey	2322 554 01181
100	12	0.25-0.40	21	3	3,0	brown	red	black	2322 554 01201
100	15	0.25-0.40	26	3	3,0	brown	red	red	2322 554 01221
100	18	0.25-0.40	32	3	3,05	brown	red	yellow	2322 554 01241
10	12	0.25-0.40	38	3	3,05	red	red	black	2322 554 02201
10	15	0.25-0.40	47	3	3,1	red	red	red	2322 554 02221
10	18	0.21-0.35	57	3	3,1	red	red	yellow	2322 554 02241
10	22	0.21-0.35	60	3	3,2	red	red	blue	2322 554 02261
10	27	0.21-0.35	70	3	3,3	red	red	grey	2322 554 02281
10	33	0.18-0.25	84	3	3,4	red	orange	black	2322 554 02301
10	39	0.18-0.25	97	3	3,45	red	orange	red	2322 554 02321
10	47	0.18-0.25	125	5	3,5	red	orange	yellow	2322 554 02341
10	56	0.18-0.25	140	5	3,55	red	orange	blue	2322 554 02361
10	68	0.18-0.25	175	5	3,6	red	orange	grey	2322 554 02381
10	82	0.14-0.23	170	5	3,65	red	yellow	black	2322 554 02401
10	100	0.14-0.23	210	5	3,7	red	yellow	red	2322 554 02421
10	120	0.14-0.21	250	5	3,75	red	yellow	yellow	2322 554 02441
10	150	0.14-0.21	320	5	3,8	red	yellow	blue	2322 554 02461
10	180	0.14-0.21	380	5	4,2	red	yellow	grey	2322 554 02481
1	150	0.14-0.21	450	5	4,6	orange	yellow	blue	2322 554 03461
1	180	0.14-0.21	540	5	5,2	orange	yellow	grey	2322 554 03481
1	220	0.14-0.21	660	5	5,7	orange	green	black	2322 554 03501
1	270	0.14-0.21	810	5	5,7	orange	green	red	2322 554 03521
1	330	0.14-0.21	980	5	6,0	orange	green	yellow	2322 554 03541

1) For a voltage tolerance of ± 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

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

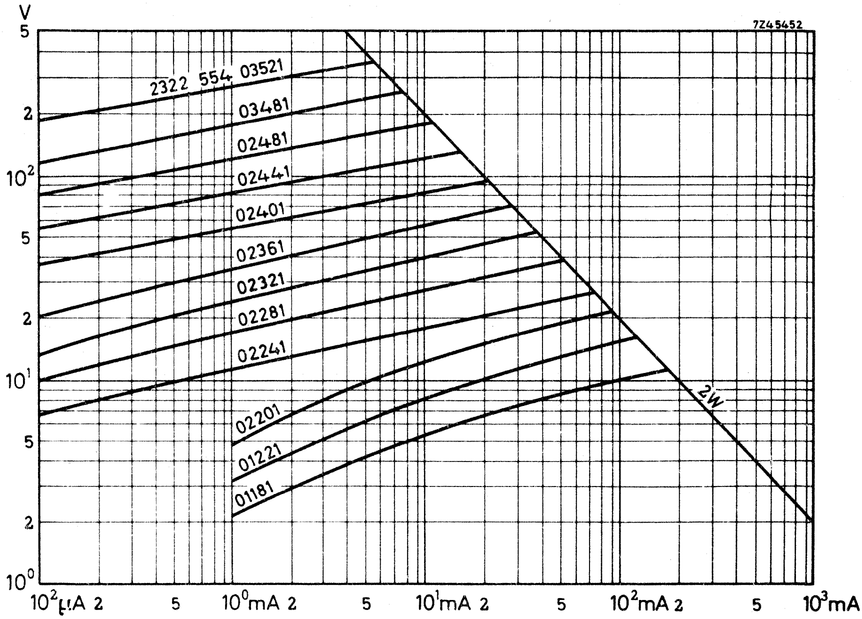


Fig. 2. Voltage/current characteristics

[1]) Also available with a tolerance of 10%.
The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

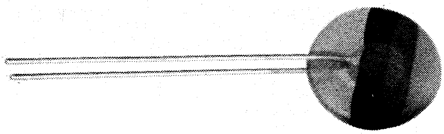
Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 50 items.

VOLTAGE DEPENDENT RESISTORS
standard disc type with leads



RZ 19624-1

QUICK REFERENCE DATA	
Voltages at I_{nom} = 100 mA d.c.	8 to 33 V
Voltages at I_{nom} = 10 mA d.c.	22 to 270 V
Voltages at I_{nom} = 1 mA d.c.	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	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

Very suitable for e.g. voltage stabilisation, contact protection and spark suppression.

DESCRIPTION

This type consists of a disc provided with two solid tinned copper wires. The resistor body is tan lacquered and impregnated, but non insulated.

MECHANICAL DATA

Dimensions in mm

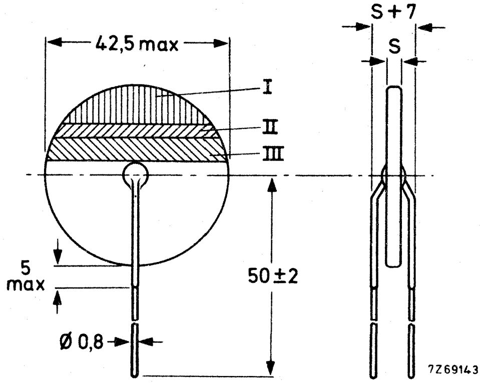


Fig. 1. For S see Table 1

Marking

The resistors are marked with three colour bands according to Fig. 1 and Table 1.

Weight

See Table 1

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

ELECTRICAL DATA

d.c. current I_{nom} (mA)	voltage at I_{nom} (V)	β	C approx.	S max. Fig.1 (mm)	weight approx. (g)	colour code 2)			catalogue number 1)
						I	II	III	
100	8	0.25-0.40	14	3	8	brown	brown	blue	2322 555 01161
100	10	0.25-0.40	18	3	8	brown	brown	grey	2322 555 01181
100	12	0.25-0.40	21	3	8	brown	red	black	2322 555 01201
100	15	0.25-0.40	26	3	8	brown	red	red	2322 555 01221
100	18	0.25-0.40	32	3	8	brown	red	yellow	2322 555 01241
100	22	0.25-0.40	39	3	8	brown	red	blue	2322 555 01261
100	27	0.25-0.40	48	3	8	brown	red	grey	2322 555 01281
100	33	0.21-0.35	53	3	8	brown	orange	black	2322 555 01301
10	22	0.21-0.35	60	3	8	red	red	blue	2322 555 02261
10	27	0.21-0.35	70	3	8	red	red	grey	2322 555 02281
10	33	0.18-0.25	84	3	8	red	orange	black	2322 555 02301
10	39	0.18-0.25	97	3	8	red	orange	red	2322 555 02321
10	47	0.18-0.25	125	5	10	red	orange	yellow	2322 555 02341
10	56	0.18-0.25	140	5	10	red	orange	blue	2322 555 02361
10	68	0.18-0.25	175	5	10	red	orange	grey	2322 555 02381
10	82	0.14-0.23	170	5	10	red	yellow	black	2322 555 02401
10	100	0.14-0.23	210	5	10	red	yellow	red	2322 555 02421
10	120	0.14-0.21	250	5	10	red	yellow	yellow	2322 555 02441
10	150	0.14-0.21	320	5	10	red	yellow	blue	2322 555 02461
10	180	0.14-0.21	380	5	10	red	yellow	grey	2322 555 02481
10	220	0.14-0.21	460	5	10	red	green	black	2322 555 02501
10	270	0.14-0.21	550	5	10	red	green	red	2322 555 02521
1	220	0.14-0.21	660	5	10	orange	green	black	2322 555 03501
1	270	0.14-0.21	810	5	10	orange	green	red	2322 555 03521
1	330	0.14-0.21	980	5	10	orange	green	yellow	2322 555 03541

1) For a voltage tolerance of ± 10% the last figure of the catalogue number is 2 instead of 1.
2) The 10% types have an extra silver band on the top.

Tolerance on voltage at I_{nom}	± 20% [1]
Maximum dissipation	3 W
Asymmetry	max. 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

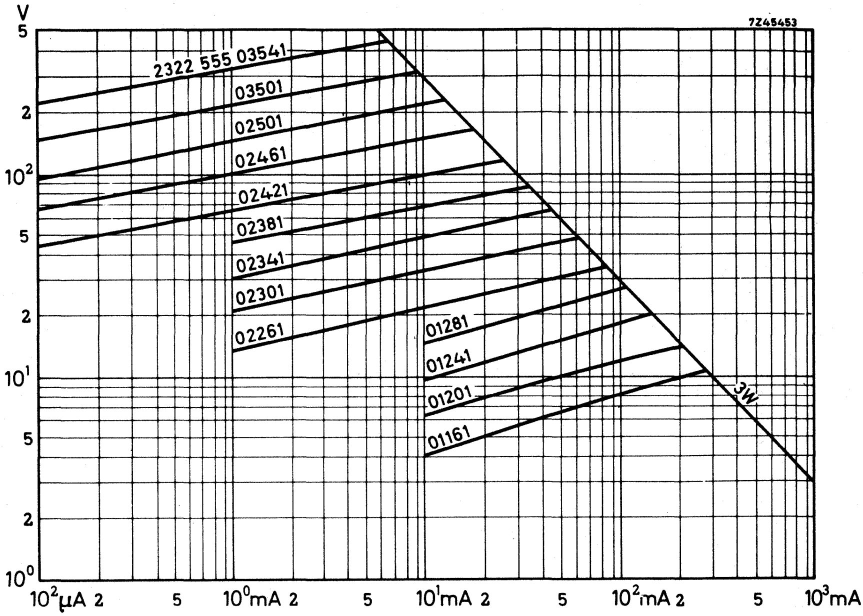


Fig.2. Voltage/current characteristics

1) Also available with a tolerance of 10%. The voltage is so measured that the internal heat development is negligible.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔV/V (%)	Δβ/β (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Damp heat at +40 °C	Ca	1000 h	± 3	± 5
Dissipation in damp heat		336 h	± 3.5	± 7
Max. dissipation at T_{amb} = +25 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 25 items.

VOLTAGE DEPENDENT RESISTORS

rod type

QUICK REFERENCE DATA	
Voltages	
types with I_{nom} = 10 mA d.c.	470 to 1300 V
type with I_{nom} = 2 mA d.c.	950 V
types with I_{nom} = 1 mA d.c.	56 to 300 V
β-values	0,16 to 0,36
Maximum dissipation	0,8 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

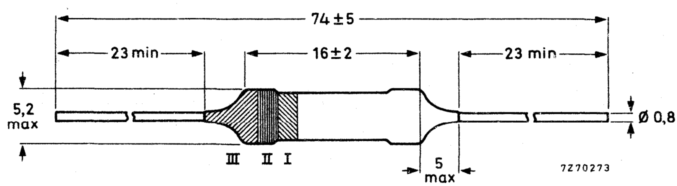
To be used for stabilization of voltages, protection of contacts, etc.

DESCRIPTION

These rods are provided with two axial solid tinned copper wires. They are tan lacquered, but not insulated.

MECHANICAL DATA

Dimensions (mm)



Marking

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

Weight 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

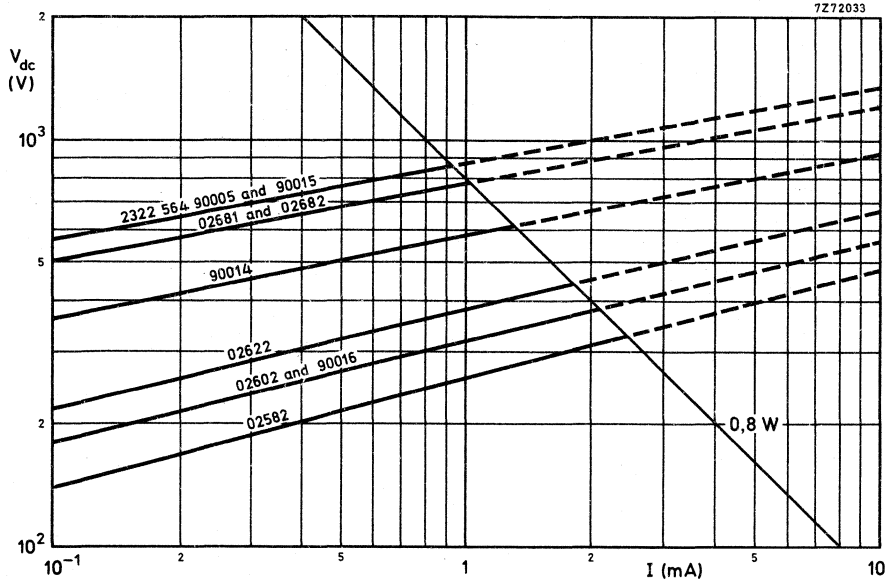
d.c. current I_{nom} (mA)	voltage at I_{nom} (V) [1]	tolerance %	β-value	colour code (see Fig. 1)			catalogue number
				band I	band II	band III	
10	470	± 10	0, 20-0, 25	green			2322 564 02582
10	560	± 10	0, 18-0, 23	blue			2322 564 02602
10	680	± 10	0, 18-0, 23	violet			2322 564 02622
10	1200	± 20	0, 17-0, 22	grey			2322 564 02681
10	1200	± 10	0, 17-0, 22	brown			2322 564 02682
10	910	± 10	0, 17-0, 22	white			2322 564 90014
10	1300	± 10	0, 16-0, 21	red			2322 564 90015
2	950	± 10	0, 16-0, 21	black	blue		2322 564 90005
1	300	± 20	0, 18-0, 25	yellow	-	-	2322 564 90016
1	56	± 20 [2]	0, 29-0, 36	orange	orange	blue	2322 564 03361
1	68	± 20 [2]	0, 29-0, 36	orange	orange	grey	2322 564 03381
1	82	± 20 [2]	0, 29-0, 36	orange	yellow	black	2322 564 03401
1	100	± 20 [2]	0, 25-0, 32	orange	yellow	red	2322 564 03421
1	120	± 20 [2]	0, 25-0, 32	orange	yellow	yellow	2322 564 03441
1	150	± 20 [2]	0, 22-0, 29	orange	yellow	blue	2322 564 03461
1	180	± 20 [2]	0, 22-0, 29	orange	yellow	grey	2322 564 03481
1	220	± 20 [2]	0, 21-0, 28	orange	green	black	2322 564 03501
1	270	± 20 [2]	0, 21-0, 28	orange	green	red	2322 564 03521

Dissipation factor	20 mW/°C
Temperature coefficient at 1 mA between +25 and +100 °C	-0, 1 %/°C
Maximum dissipation	0, 8 W
Asymmetry	max. 2% [3]
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

[1]) The voltage is so measured, that the internal heat development is negligible.

[2]) For a voltage tolerance of 10% the last figure of the catalogue number is 2 instead of 1.

[3]) Covered by the specified voltage tolerance



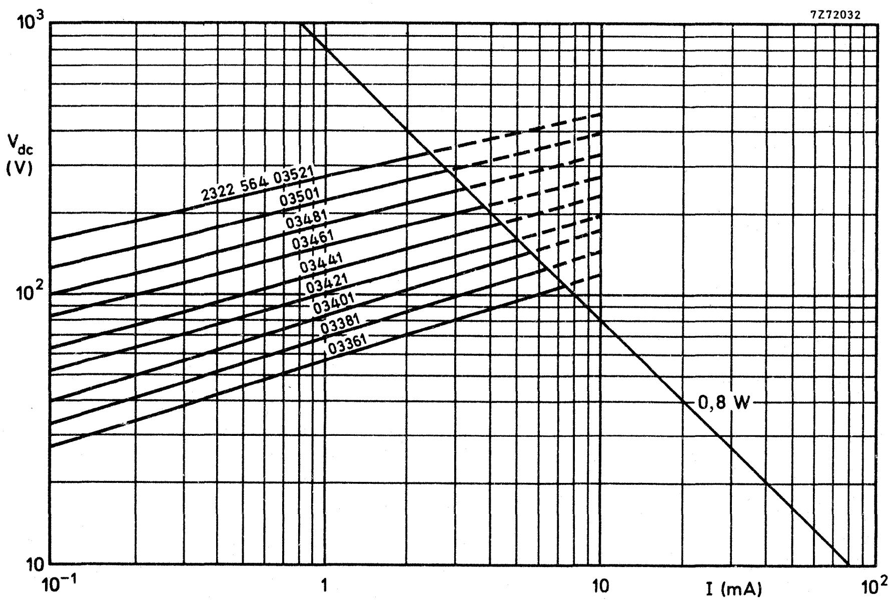


Fig. 2a and b. Typical voltage/current characteristics measured under pulse conditions.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test [1]	test method	duration	ΔV/V (%) at I_{nom}	$\Delta \beta/\beta$ (%)
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 2	± 3
Dry heat at +125 °C	B	1000 h	± 3	± 5
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 5
Max. dissipation		1000 h	± 5	± 7,5
Robustness of terminations	U			
Tensile strenght 20 N	Ua	10 s	[2]	
Bending 10 N	Ub	2 times	[2]	
Torsion	Uc	3 times	[2]	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	[3]	
Resistance to heat at 260 ± 5 °C	Tb	10 to 11 s	± 2	± 2

[1]) For d.c. measurements the measuring current must have the same polarity as the load current.

[2]) Leads should neither come loose nor break.

[3]) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

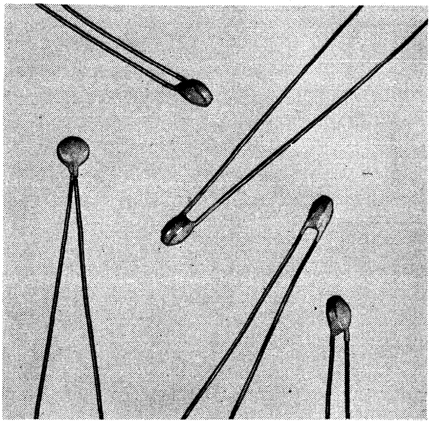
A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

Cardboard boxes containing 100 items.

VOLTAGE DEPENDENT RESISTORS

small disc types for special purposes



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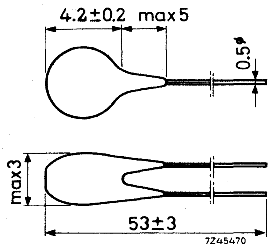


Type 2322 565 90001 has been developed for use in small battery motors, for example. It can be mounted in the rotor to protect the collector and to suppress interference to radio and television.

Current at 5 V d.c. $\leqslant$ 1 mA
Current at 28 V d.c. $\geqslant$ 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	cat. no. 2322 565
1	6	± 20%	red	90002
1	9	± 20%	orange	90003
1	12	± 15%	yellow	90004
1	15	± 15%	green	90005
1	18	± 12%	blue	90006

VOLTAGE DEPENDENT RESISTOR

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. 0,20 to 0,28
Maximum dissipation	0,25 W
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

APPLICATION

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

DESCRIPTION

This type consists of a titanium oxide disc provided with two solid tinned copper wires. The resistor body is tan lacquered but not insulated.

MECHANICAL DATA

Dimensions (mm)

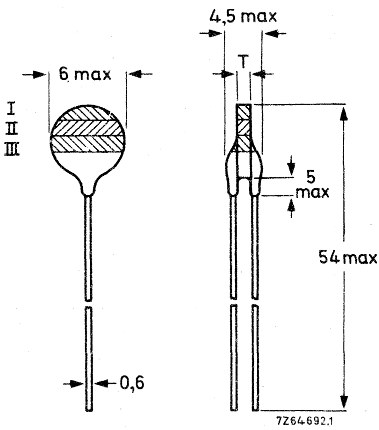


Fig. 1.

Marking

The resistors are marked with three colour bands (see Fig. 1) according to the table.

Mass

0,25 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. 240 °C, max. 4 s

ELECTRICAL DATA

d.c. voltage at 1 mA V	max. β between 1 – 10 mA	capacitance nF	colour code I	II	III	catalogue number (20% tolerance on voltage) *
2,7	0,28	40	orange	black	yellow	2322 581 03041
3,3	0,28	35	orange	black	blue	03061
3,9	0,28	29	orange	black	grey	03081
4,7	0,25	24	orange	brown	black	03101
5,6	0,25	21	orange	brown	red	03121
6,8	0,22	18	orange	brown	yellow	03141
8,2	0,22	16	orange	brown	blue	03161
10	0,22	14	orange	brown	grey	03181
12	0,22	12	orange	red	black	03201
15	0,22	11	orange	red	red	03221
18	0,22	9,5	orange	red	yellow	03241
22	0,20	8	orange	red	blue	03261
27	0,20	7	orange	red	grey	03281
33	0,20	5,5	orange	orange	black	03301
39	0,20	5	orange	orange	red	03321
47	0,20	4	orange	orange	yellow	03341
56	0,20	3	orange	orange	blue	03361
68	0,20	2	orange	orange	grey	03381

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

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
Symmetry after any measurement	< 2%
Operating temperature range	
at zero power	−25 to +125 °C
at maximum power	0 to +55 °C

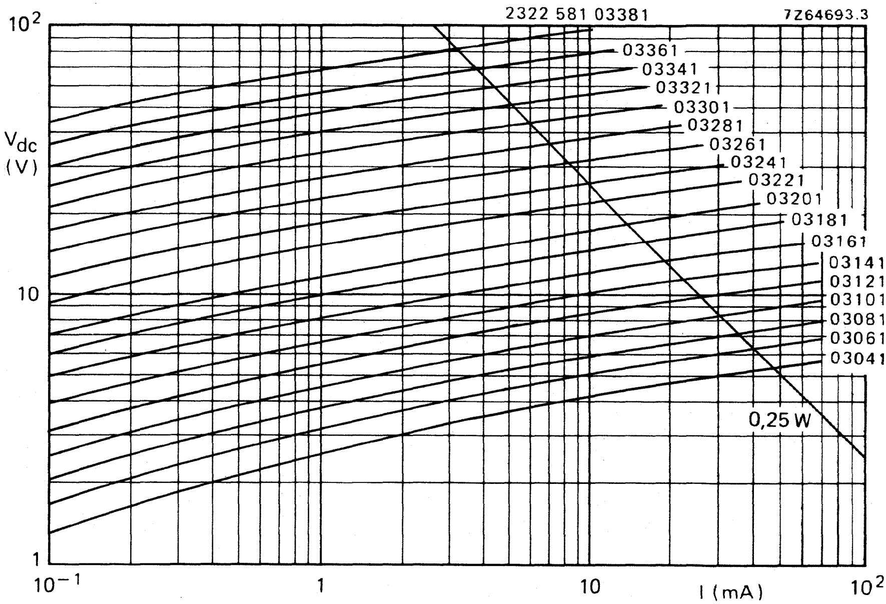


Fig. 2 Typical voltage/current characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test (note 1)	test method	duration	ΔV/V (%) at 1 mA	ΔV/V (%) at 10 mA
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat + 85 °C	B	1000 h	± 5	± 5
Thermal shock −25 °C to +85 °C	Na	5 cycles	± 3	± 3
Damp heat at +40 °C	C	56 days	± 5	± 5
Climatic sequence	(note 2)		± 5	± 5
Maximum dissipation at T_{amb} = +55 °C		1000 h	± 5	± 5
Robustness of terminations	U			
Tensile strength	Ua	10 s	(note 3)	
Bending	Ub	2 times	(note 3)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s once	(note 4)	
Resistance to heat	Tb	10 ± 1 s once	± 2	± 2
Impact, free fall	Ed	2 falls	(note 5)	

Notes

1. For d.c. measurements the measuring current must have the same polarity as the load current.
2. CECC par. 4.16. secr. 333 Jan. 1975.
3. Leads should neither come loose nor break.
4. Leads must be solderable initially and after 6 months storage with solder containing resin flux.
5. Neither electrical nor visual defects will be stated.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D:

A.Q.L. 1%, critical defects – Electrical.
A.Q.L. 1,5%, major defects – Mechanical.
A.Q.L. 4%, minor defects – Physical.

VOLTAGE DEPENDENT RESISTOR

disc type for contact protection

QUICK REFERENCE DATA

Nominal voltage	48 V d.c.
Max. current at nominal voltage	0,05 mA
Max. voltage at current for efficiency test (152 mA)	135 V
Nominal dissipation	0,1 W
Climatic category (NF C 20-600, par. 4.3)	454 (55/085/56)
Operating temperature range, up to 48 V + 20%	−55 to +85 °C

APPLICATION

This VDR has been developed to protect relay contacts in telephone exchanges and to prolong their life considerably.

DESCRIPTION

The VDR consists of a disc provided with two solid tinned wires. The body is white lacquered, but not insulated.

The data given below fully conform with the French standards NF C 93-277 of January 1973, and UTE C 93-277 of 21 November 1972, article sheet 3. It has official French approval (Comité de coordination des télécommunications, certificate number 73-209 of 30 August 1973) and official Belgian approval (Comité électrotechnique belge, certificate number H 002 of 1 February 1972).

MECHANICAL DATA

Dimensions (mm)

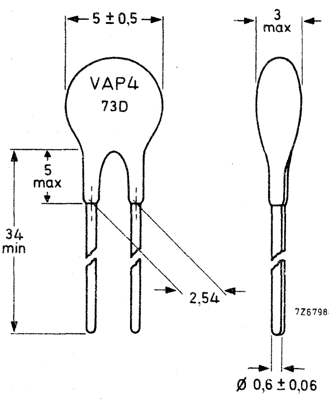


Fig. 1.

Mass

0,25 g approximately

Mounting

In any position by soldering

Marking

The VDR bears the following indications (see also Fig. 1):
a. VAP4;
b. 3 characters for year and month of production;
c. manufacturer's identification symbol ⍼.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 350 °C, max. 4 s

Inflammability

Self-extinguishing within 5 s, according to NF C 93-001, add. 1 par. 5.22.

ELECTRICAL DATA

Nominal voltage	48 V d.c.
Max. current at nominal voltage (NF C 93-277, class 7)	0,05 mA
Max. voltage at current for efficiency test (152 mA)	135 V
β-value between 0,1 mA and 1 mA	typ. 0,035
Dissipation factor	8 mW/K approx.
Temperature coefficient (method B)	max. 0,1%/K
Nominal dissipation	0,1 W
Asymmetry at current for efficiency test (152 mA)	max. 2%
Climatic category (NF C 20-600, par. 4.3)	454 (55/085/56)
Operating temperature range, up to 48 V + 20%	−55 to +85 °C

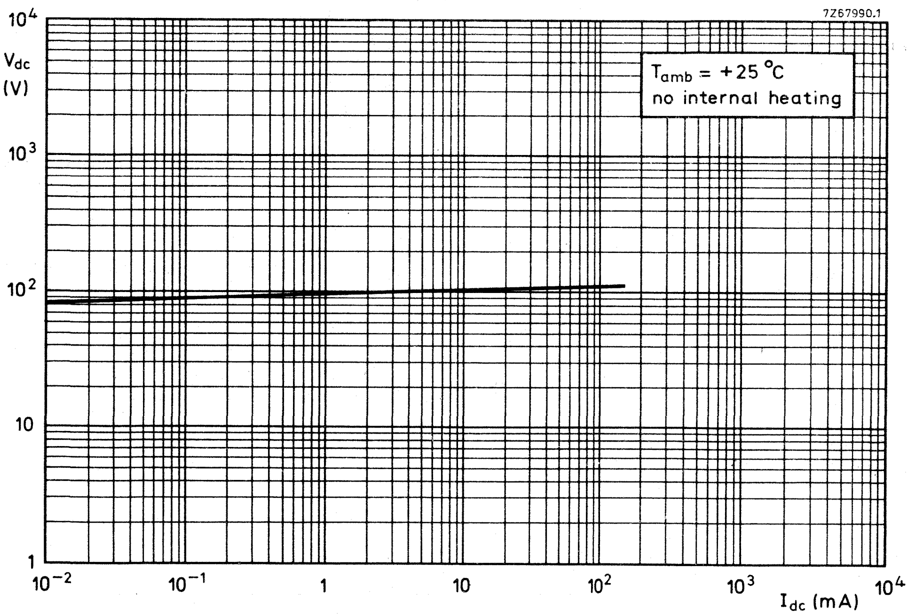


Fig. 2 Typical voltage/current characteristic.

TESTS AND REQUIREMENTS

According to specification NF C 93-277

Table 1

test	test method	requirements
Stability after over-voltage	3.2.3	I max. 0,05 mA no damage, marking legible
Combined climatic test	3.3.1	I max. 0,05 mA no damage, marking legible
Damp heat	3.3.2	I max. 0,05 mA no damage, marking legible
Rapid change of temperature	3.3.3	I max. 0,05 mA no damage, marking legible
Robustness of terminations	3.3.4	no mechanical damage
Solderability	3.3.5	good tinning
Resistance to heat	3.3.6	I max. 0,05 mA no damage, marking legible
Inflammability	3.3.7	self-extinguishing; no significant mechanical damage other than changes in colour of the body, or in the quality of the marking.
Accelerated aging	3.4.1	I max. 0,05 mA no damage, marking legible; max. voltage at current for efficiency test must remain as specified
Endurance	3.4.2	I max. 0,05 mA no damage, marking legible; max. voltage at current for efficiency test must remain as specified

PACKING

500 pieces per box (cardboard)

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 energy	
2322 592 series	1,3 to 7,7 J
2322 594 series	3 to 24 J
Operating temperature range	
at zero power	−40 to + 125 °C
at maximum power	−40 to + 85 °C

APPLICATION

Suppression of voltage transient, contact protection, spark suppression.

DESCRIPTION

The VDRs consist of a disc of low-β material, which is provided with two solid tinned copper wires. They are white lacquered, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

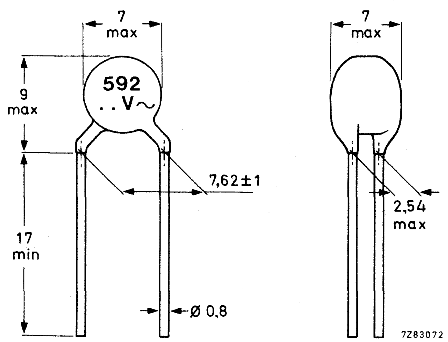


Fig. 1 2322 592 series.

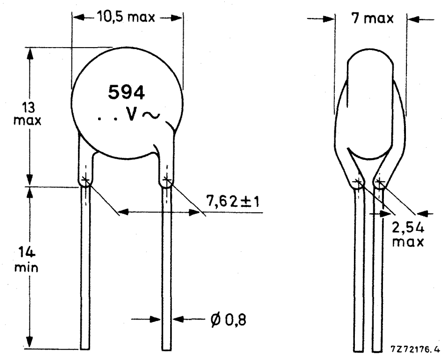


Fig. 2 2322 594 series.

Marking

The resistors are marked with their serial number and the maximum r.m.s. working voltage (see Figs 1 and 2, and Tables 1 and 2).

Mass

2322 592 series 0,8 g approx., 2322 594 series 1 g approx.

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

Inflammability

Self-extinguishing

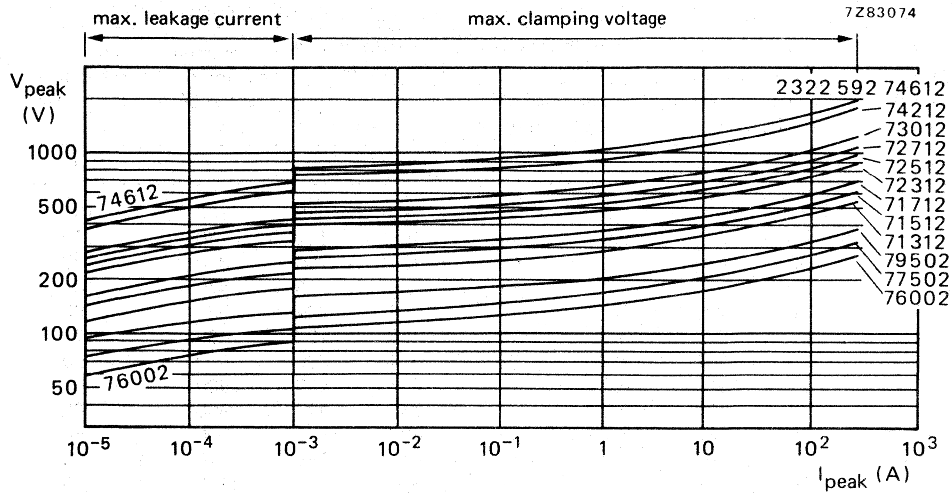
ELECTRICAL DATA

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

		2322 592	2322 594	
Thermal resistance, body to air	approx.	80	65	K/W
Temperature coefficient at 1 mA, measured between + 25 and + 85 °C	approx.	−0,065	−0,065	%/K
Maximum average dissipation (including transients)		100	300	mW
Maximum impulse current (8/20 μs)*		250	500	A
Operating temperature range				
at zero power		−40 to + 125		°C
at maximum power		−40 to + 85		°C
Climatic category		40/125/56		

See further Tables 1 and 2

* This current is determined by the width T_2 (see Fig. 5) and the number of impulses expected during the life of the component. Figure 6 gives the derating for different numbers of impulses. Resulting energy can be calculated with the equation: $E = K.V_p.I_p.T_2$.



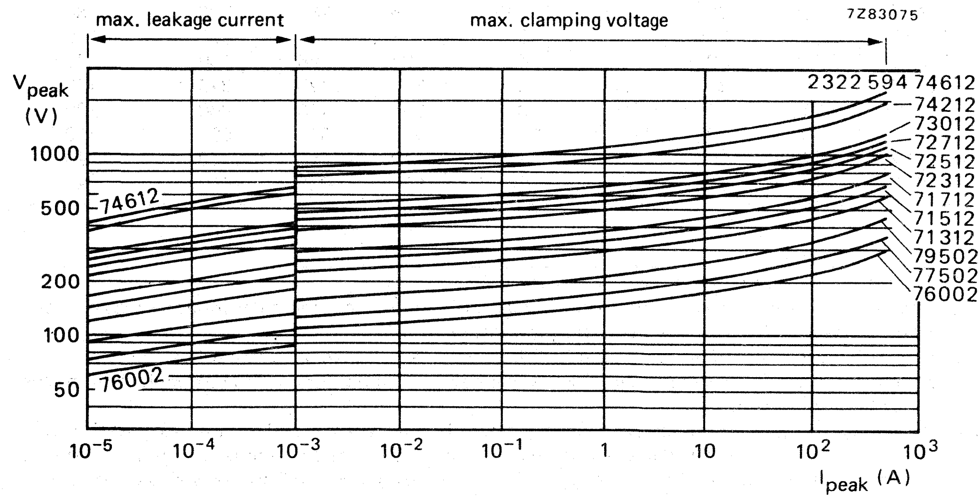


Fig. 3 V/I characteristics.

Table 1 VDRs with catalogue number 2322 592 .....

suffix of catalogue number	MAXIMUM RATINGS				CHARACTERISTICS			
	r.m.s. working voltage (note 2)	d.c. working voltage	transient energy		varistor voltage (note 1)		maximum clamping voltage at 50 A	typical capacitance at 10 kHz
			8/20 μs (note 3)	10/1000 μs (note 4)	min.	max.		
	V	V	J	J	V	V	V	pF
76002	60	85	1,3	1,6	90	110	230	180
77502	75	100	1,5	1,9	108	132	280	150
79502	95	125	1,8	2,2	135	165	350	120
71312	130	170	2,4	3,1	185	225	470	100
71512	150	200	2,9	3,7	216	264	560	80
71712	175	225	3,3	4,0	243	297	630	70
72312	230	300	4,4	5,5	324	396	830	60
72512	250	320	4,8	6,0	351	429	900	60
72712	275	350	5,3	6,8	387	473	990	60
73012	300	385	5,7	7,4	423	517	1090	50
74212	420	560	6,2	10,7	612	748	1570	50
74612	460	615	7,7	11,8	675	825	1730	50

Table 2 VDRs with catalogue number 2322 594 .....

							at 100 A	
76002	60	85	3,0	2,3	90	110	220	420
77502	75	100	3,5	2,8	108	132	260	350
79502	95	125	4,5	3,5	135	165	330	310
71312	130	170	6,5	4,8	185	225	440	280
71512	150	200	7,5	5,5	216	264	510	180
71712	175	225	9	6,2	243	297	570	170
72312	230	300	11	8,0	324	396	760	140
72512	250	320	12	8,8	351	429	820	130
72712	275	350	14	9,5	387	473	900	130
73012	300	385	15	10,5	423	517	980	110
74212	420	560	20	15	612	748	1410	90
74612	460	615	24	16	675	825	1550	90

Notes

1. Voltage at a current of 1 mA, impulse time 10 ms.
2. Sinusoidal voltage assumed as normal operating condition. If a non-sinusoidal voltage is present, the crest voltage x 0,707 should be used for type selection.
3. A current wave of 8 / 20 μs (defined in IEC 60-2 section six) 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.
4. 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 following IEC 60-2 section six), 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: for T_2 = 20 μs K = 1; for 50 μs 1,2; for 100 μs 1,3; for 1000 μs 1,4.

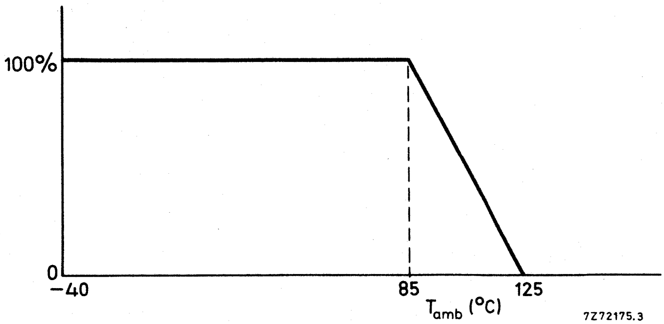


Fig. 4 Derating of max. d.c. and r.m.s. working voltage with temperature.

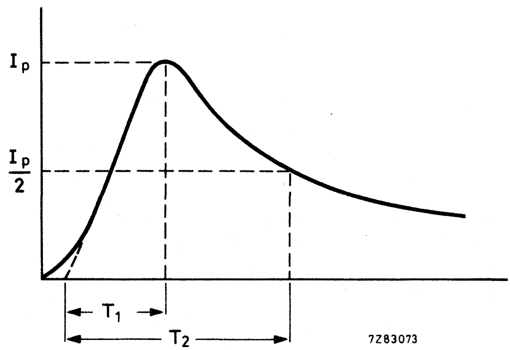
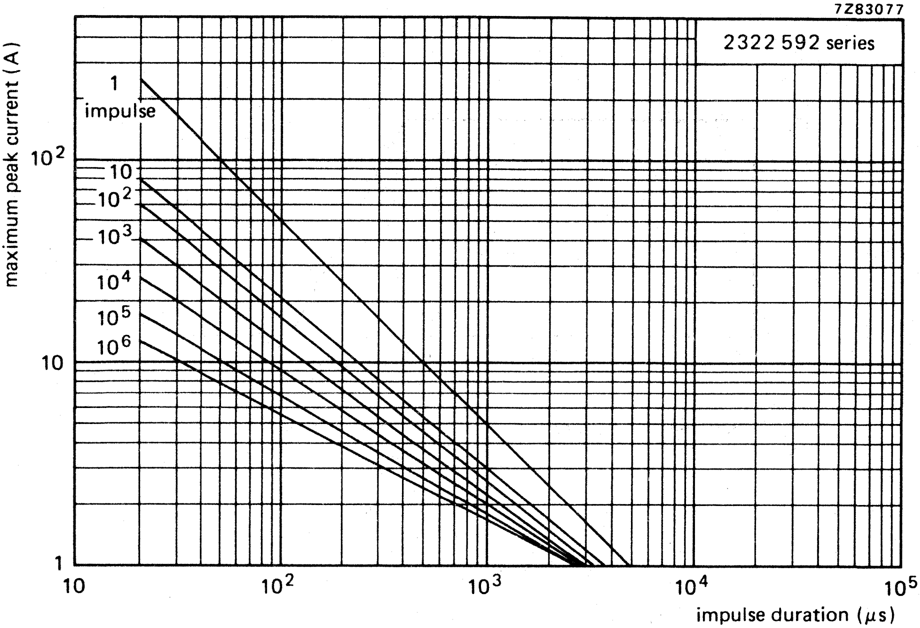


Fig. 5.



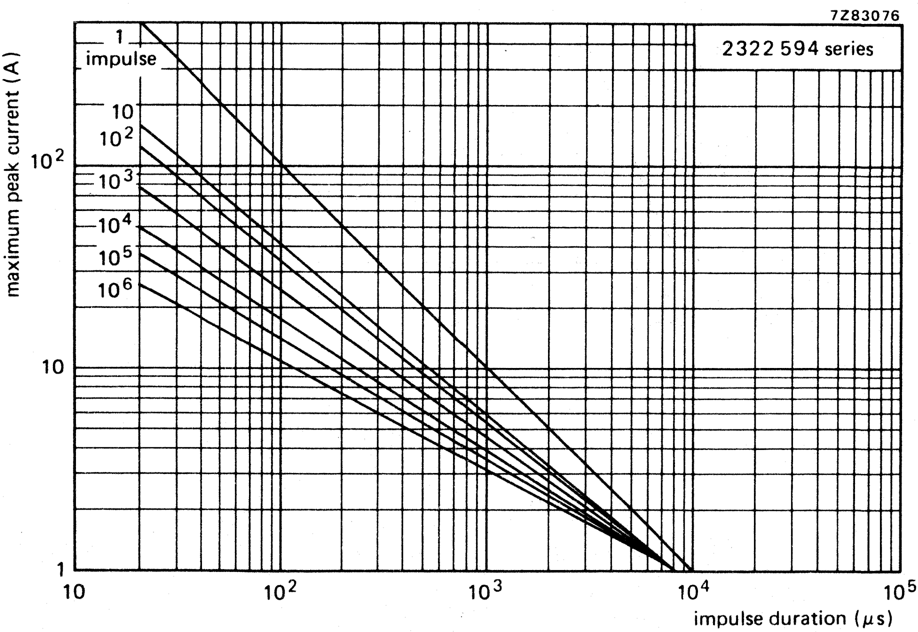


Fig. 6 Max. applicable transient current as a function of impulse duration.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔV/V (%) at I_{peak} = 1 mA
Cold at –40 °C	A	1000 h	± 3
Storage at + 25 °C	H	1000 h	± 3
Dry heat at + 125 °C	B	1000 h	± 5
Rapid change of temperature	Na	5 cycles	± 5
Damp heat at + 40 °C	C	56 days	± 5
Climatic sequence	(note 2)		± 5
Pulse tests			
High current transients at + 25 °C	(notes 1, 7, 9)	10 pulses 8 / 20 μs	± 5
Long duration transients	(notes 1, 8, 9)	10 pulses 10 / 1000 μs	± 5
Electrical endurance at + 85 °C			
Maximum r.m.s. voltage	(note 6	1000 h	± 5
Maximum d.c. voltage	(notes 1, 6)	1000 h	± 5
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 3)
Bending	Ub	2 times	(note 3)
Soldering	T		
Solderability	par. 3.2.3.	3 to 4 s	(note 4)
Resistance to heat	Tb	10 to 11 s	± 5
Impact	E		
Free fall	Ed	2 falls	(note 5)

Notes

1. For d.c. measurements the measuring current must have the same polarity as the load current.
2. CECC 42000 issue 1 1978, par. 4. 16. Damp heat cycle test replaced by damp heat steady state for 24 h.
3. Leads should neither come loose nor break.
4. Leads must be solderable initially and after 6 months storage with solder containing resin flux.
5. Neither electrical nor visual defects.
6. CECC 42000 par. 4. 20.
7. One impulse/min, all impulses same polarity, 2322 592 series I_p = 80 A, 2322 594 series I_p = 165 A.
8. One impulse/min, all impulses same polarity, 2322 592 series I_p = 3 A, 2322 594 series I_p = 6 A.
9. Impulse shape acc. to IEC 60-2 section six "Tests with impulse currents".

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 0,25%, Inoperatives
A.Q.L. 1%, Electrical
A.Q.L. 1,5%, Mechanical

PACKING

250 pieces per box (cardboard).

LIGHT DEPENDENT RESISTORS (LDR)

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Introduction	3
Electrical properties	5
How to measure LDRs	7
Data sheets	9

SURVEY

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

Recovery rate min. 200 kΩ/s

INTRODUCTION

L(ight) D(ependent) R(esistors) are made from cadmium sulphide, a material which, when prepared properly, contains no or very few free electrons when kept in complete darkness. Its resistance is therefore quite high. When it absorbs light, electrons are liberated and thus the material becomes more conducting. Cadmium sulphide is therefore called a photoconductor. The electrons are free only for a limited time and when the light is switched off, they are captured again by those places where they originally came from and thus the conductor turns again to an insulator.

Let us consider a disk of cadmium sulphide provided with two electrodes (Fig.1). The distance between the electrodes is d and the length is l. When the disk is exposed to an illumination L a number of electrons N are liberated per second in the disk between the two electrodes:

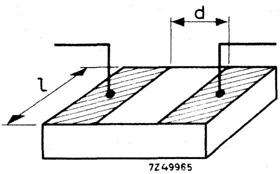


Fig.1

$$N = \eta \, L \, l \, d \qquad (1)$$

where η is a constant depending on the wave length of the light. When a voltage V is applied to the electrodes the electrons move with a velocity v which is proportional to the field strength E:

$$v = \mu E = \frac{\mu V}{d} \qquad (2)$$

The proportionality constant μ is called the mobility. Not all electrons may reach the positive electrode but only those which are liberated within a distance v τ from this electrode when τ = average life time of a free electron. The fraction of the electrons that contribute to the current is therefore $\frac{v\,\tau}{d}$ (3)

and the measured photocurrent i is from (1), (2) and (3) given by:

$$i = Ne\frac{v\,\tau}{d} = \frac{\eta\, e\mu\, \tau\, lLV}{d} \qquad (4)$$

where e = electric charge of an electron.

The resistance R, caused by the illumination, is then:

$$R = \frac{V}{i} = \frac{d}{\eta\, e\mu\, \tau\, l}\, L^{-1} \qquad (5)$$

The life time τ is usually not constant but depends on the wave length λ of the light and on the illumination L:

$$\tau = \tau_o (\lambda) L^{-\beta} \tag{6}$$

The relation between the resistance and the illumination can therefore be expressed in good approximation by

$$R = A L^{-\alpha} \tag{7}$$

From (6) and (7)

$$A = \frac{d}{\eta e \mu \tau_o l} \tag{8}$$

To have a sensitive L D R it is important to make A as low as possible. This can be done by choosing the right material such as cadmium sulphide with a high value of η, μ and τ_o, and by making $\frac{l}{d}$ as large as possible. The latter is done by making a long and narrow slit and then folding it up as it were on a small area. This is accomplished by giving the electrodes an interdigital comb-like structure.

MANUFACTURING PROCESS

Highly purified cadmium-sulphide powder mixed with suitable additives is pressed in the form of discs.
The discs are sintered at a high temperature and carefully controlled conditions such as atmospheric pressure, temperature and time.
The electrodes are applied by vacuum evaporation. Afterwards leads are fixed to the electrodes and the LDR disc with leads is mounted in a suitable casing or covered by a special lacquer.

ELECTRICAL PROPERTIES

RESISTANCE/ILLUMINATION CHARACTERISTICS

As shown in the introduction the relationship between resistance value and illumination can be expressed with good approximation by the formula (7):

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

where R = resistance value in Ω
L = illumination in lux (see under "photometric concepts, definitions and units").
A and α are constants

The value of α depends e.g. on the cadmium sulphide used and the manufacturing process. Values around 0.7-0.9 are quite normal. In Fig.2 the relationship between the resistance R and the illumination in lux is depicted for a normal LDR type.

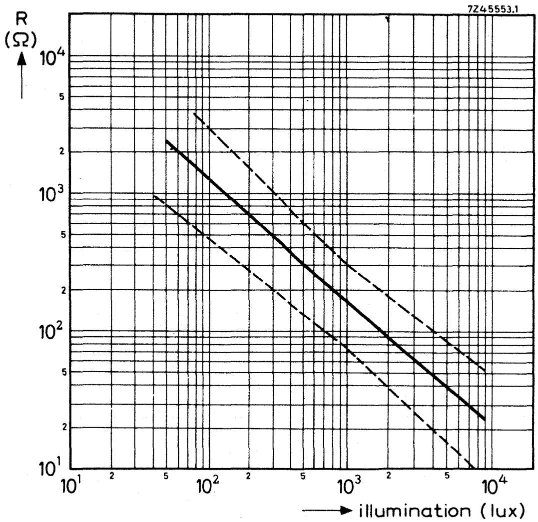


Fig.2.
Resistance/illumination characteristic of an LDR

SPECTRAL RESPONSE

LDR's only produce an electric effect with the incident radiation of a limited range of wavelengths. At the red end of the spectrum there is a threshold wavelength above which no photoelectric effect can occur. The photons (hv) of the radiation beyond that wavelength carry insufficient energy to liberate electrons. At wavelengths lower than the threshold value the response increases at first because η increases and more electrons are excited. There is, however, a critical wavelength below which the response decreases mainly because of a decrease in life time of the excited electrons.

The spectral response curve is a curve which shows the relationship between the resistance properties and the wavelength of the incident flux, the ordinates indicating the ratio of the resistance at any given wavelength to the resistance at a wavelength where the resistance is a maximum. The spectral sensitivity is determined by the properties of the photosensitive material. LDR's have their maximum response at about 6800 °A (see Fig.3).

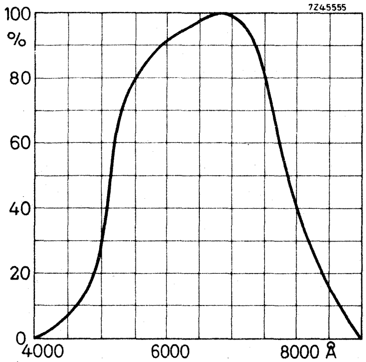


Fig.3.
Spectral response characteristic of an LDR

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, it can be observed that the resistance value of the LDR does not increase immediately to the dark value but only reaches it after a certain time. The recovery rate is a practical measure for the increase in resistance value in time. It 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 speed 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 value which corresponds with a light level of 400 lux.

HOW TO MEASURE LDR RESISTORS

Preconditioning

Before starting measurements the LDR's have to be adapted to darkness for at least 16 hours. Then, during a minimum of 1 hour and a maximum of 2 hours the LDR's must be exposed to an illumination of 1,000 lux.

Mounting

The LDR must be mounted in a blackened box or cylinder in such a way that reflections on the surface of the LDR are avoided entirely.
The distance between the lamp and the LDR must be so that the unloaded LDR does not reach a temperature above 30 ^{o}C.

Illumination

The illumination source must be a voltage stabilized incandescent lamp with a colour temperature of 2850 $^{o}K \pm 150$ ^{o}K.

Measuring the light resistance R_L

After preconditioning R_L can be measured at an illumination level of 1,000 lux. The measuring voltage has to be adjusted so that the dissipation in the LDR is less than 50 mW. The light level is controlled by a reference cell, situated at the same level as the LDR.

Measuring the dark resistance R_D

The dark resistance is measured after the LDR has been in total darkness for 30 minutes at a voltage of 20 V.

Recovery rate

When bringing an LDR from light to total darkness it takes some time before the resistance reaches an end value. The recovery rate is a check on this time, and is measured as the increase in resistance value after 20 seconds, starting from a light level of 1,000 lux. Preconditioning as above.

Drift D_L

Although not specified, it is sometimes of interest to measure the change of resistance value during a certain time at a constant light level immediately after a period of staying in total darkness.

$$D_L = \frac{R_{1L} - R_{0L}}{R_{0L}} \cdot 100\% \text{ with:}$$

R_{0L} = resistance value at t = 0 when the resistor comes out of the total darkness and is illuminated with L lux.

R_{1L} = resistance value at $t = t_1$ (1 or 2 hours), so exposed during a time t_1 to L lux.

SPREAD VALUES

The resistance illumination characteristics of LDR's are measured at two points, namely at 1,000 lux and in total darkness. At 1,000 lux a maximum and a minimum resistance value are specified. In total darkness the minimum resistance value, reached after a certain time, is specified.
As the value of α is not a constant (see section on properties of LDR's) but shows some spread, the spread at another light level may be somewhat wider than the spread values at 1,000 lux (see fig.2).

Influence of illumination level

At very high illumination levels (above 10,000 lux) the R/L characteristics tend to flatten. At this level the influence of the resistance of the electrodes (compared with the resistance of the CdS) is no longer negligible.

LIGHT DEPENDENT RESISTORS

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

APPLICATION

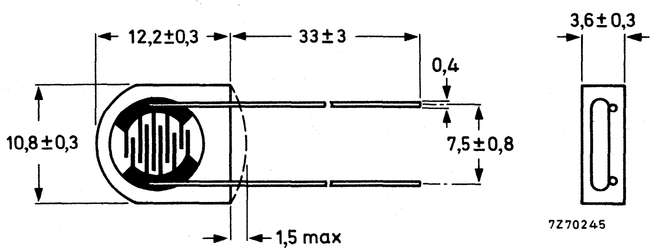
The LDR's are intended for non-critical on-off applications, in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power) e.g. in toys.

DESCRIPTION

These disc-like resistors are made of cadmium sulphide. They are provided with two solid tinned copper wires and are sealed by plastic coating.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

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
Maximum dissipation at 40 °C		0,1 W
Capacitance at 1000 Hz		max. 8 pF
Maximum repetitive peak voltage not exceeding max. dissipation		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
Ambient temperature range		−30 to +60 °C

Typical characteristics

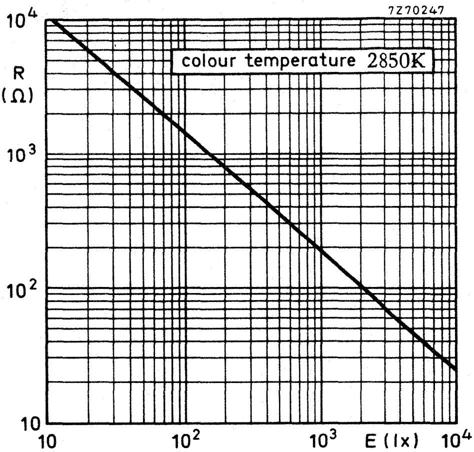


Fig. 2 Resistance as a function of illumination

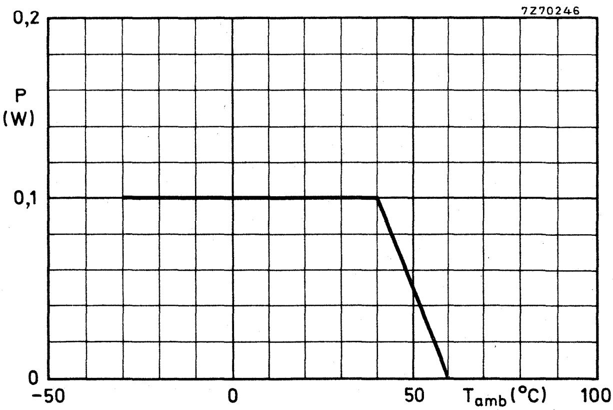


Fig. 3 Permissible dissipation as a function of ambient temperature

PACKING

100 pieces 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

APPLICATION

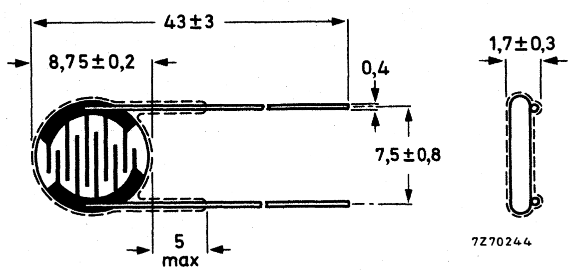
The LDR's are intended for non-critical on-off applications in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power), e.g. in toys.

DESCRIPTION

The items are made from cadmium sulphide in disc form. They are provided with two solid tinned copper wires and are covered with a transparant lacquer.

MECHANICAL DATA

Dimensions (mm)



Marking

None

Weight

0,35 g approximately

Mounting

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

Robustness of terminations

Tensile strenght	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
Maximum dissipation at 40 °C	0,1 W
Capacitance at 1000 Hz	max. 8 pF
Maximum repetitive peak voltage, not exceeding max. dissipation	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
Ambient temperature range	−30 to +60 °C

Typical characteristics

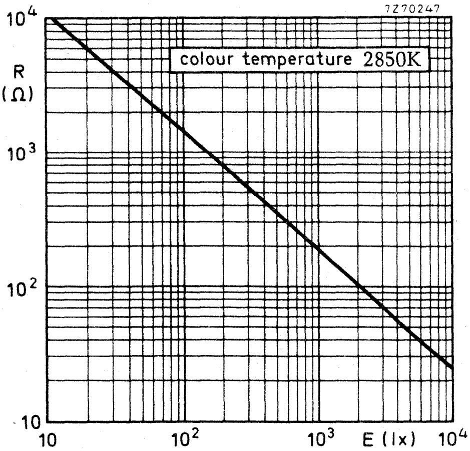


Fig. 2 Resistance as a function of illumination

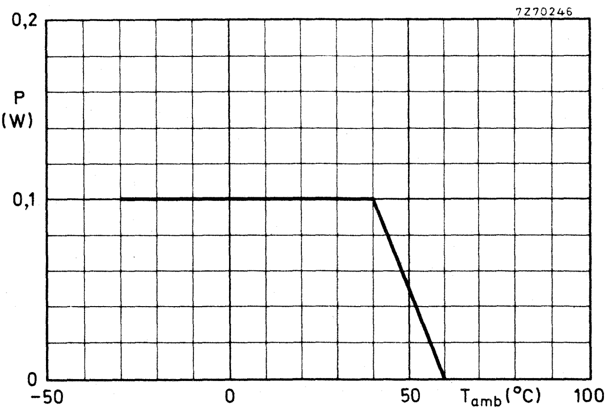


Fig. 3 Permissible dissipation as a function of ambient temperature

PACKING

100 pieces 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

APPLICATION

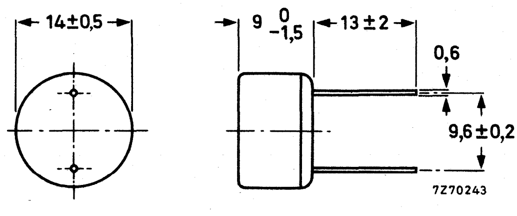
The LDR's are intended for non-critical on-off applications, in which a lamp or a relay is operated either directly (low power) or via a suitable amplifier (high power), e.g. in toys.

DESCRIPTION

These disk-like resistors are made of cadmium sulphide. They are provided with two solid tinned copper wires compounded in synthetic resin and encapsulated in plastic.

MECHANICAL DATA

Dimensions (mm)



Marking

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

Weight

1, 3 g approximately.

Mounting

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

Robustness of terminations

Tensile strenght	10 N
Bending	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
Maximum dissipation at 40 °C	0, 2 W
Capacitance at 1000 Hz	max. 6 pF
Maximum repetitive peak voltage not exceeding max. dissipation	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
Ambient temperature range	−20 to +60 °C

Typical characteristics

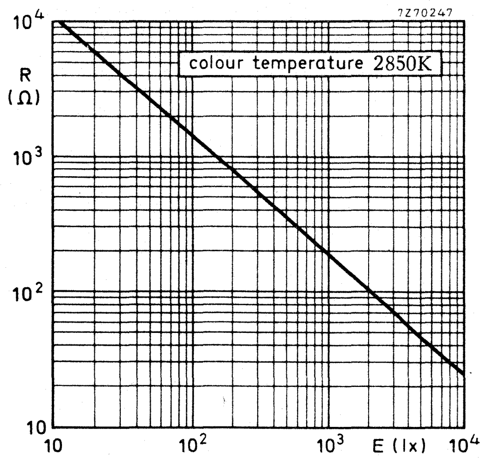


Fig. 2 Resistance as a function of illumination

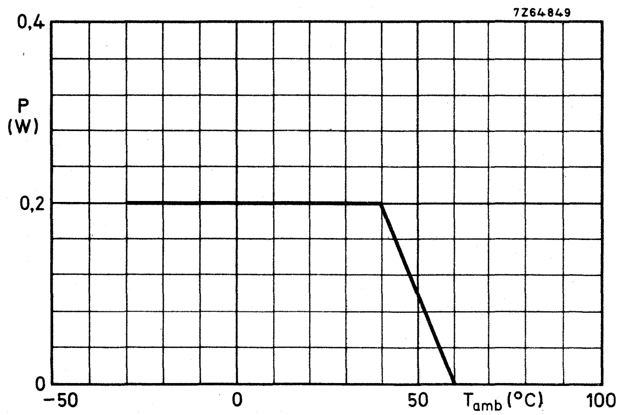


Fig. 3 Permissible dissipation as a function of ambient temperature

PACKING

500 pieces per box

NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

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Survey	2
Introduction	6
Electrical properties	8
How to measure NTC thermistors	15
Choice of type	17
Soldering disc NTC thermistors	19
Applications	21
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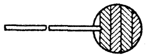
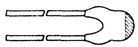
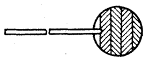
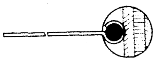
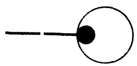
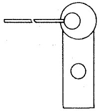
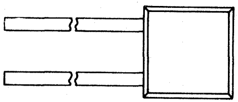
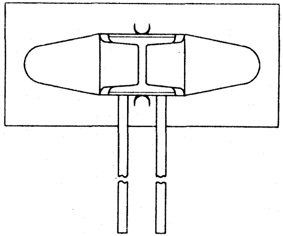
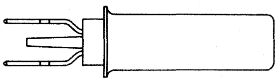
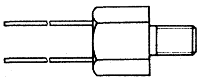
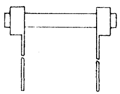
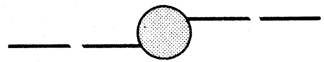
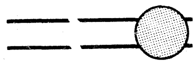
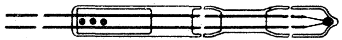
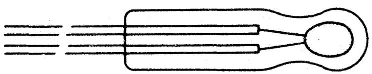
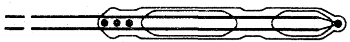
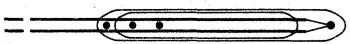
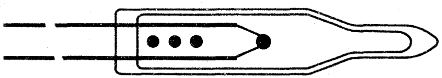
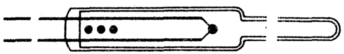
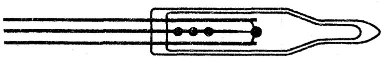
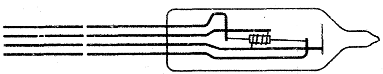
SURVEY

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 0....
		1	−25 to +125	2600 to 5450	1,1 to 1300	2322 610 1....
			25 to +100		270 to 2200	2322 611
		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	2600 to 4700	3,3 to 330 k	2322 642 1....
		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
			−25 to +155	2975	5	2322 644 90012

on metal strip 	1	–25 to +125	2800 to 5450	4 to 1300	2322 610 9....
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	3700	R_{+25} = 12000 R_{+90} = 1300	2322 640 90007 90011
	0,5	–25 to +100	2600 to 4700	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 +300	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....
	0,025	−25 to +200	2200 to 4200	680 to 1 M	2322 627 5....

	0,06	−25 to +200	2200 to 4100	680 to 680 k	2322 634 2....
	0,02	−25 to +200	2200 to 4100	680 to 680 k	2322 634 3....
		−25 to +200	2200 to 4100	680 to 680 k	2322 634 4....
INDIRECTLY HEATED 	0,035	−25 to +200	2750 and 4275	3,3 k and 330 k	2322 628 01332 01334
 *	0,025 0,025 0,020 0,025	−25 to +200 −25 to +200 −25 to +200 −25 to +200	 2500 2350 1650	1 k to 680 k 1800 1000 55	2322 628 2.... 2322 628 90008 2322 628 90009 2322 628 90011

* Detailed information available on request.

INTRODUCTION

NTC thermistors are resistors with a high negative temperature coefficient of resistance. They are prepared 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 situated near the foreign ions and again free to move through the crystals at higher temperatures. In this case virtually a positively charged particle is the mobile charge carrier and therefore these materials are called p-type semiconductors.

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

In both cases 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 an exponential one, 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. For the mobility it is not certain whether the temperature dependence is comparable to that of charge carriers in germanium-type semiconductors ($\mu \propto T^{-b}$) or comparable 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

$$\mu \propto \frac{e^{-q_2/kT}}{T} .$$

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

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

where q_2 may be zero. In practice the exponential factor is the most important one, so that the resistance variation of these thermistors in a broad temperature region can be represented by the simple formula

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

MANUFACTURING PROCESS

The manufacturing process can be compared with that used in ceramic industry. After intensive mixing and after addition of a plastic binder the mass is shaped into the appropriate forms, e.g. by extrusion (rods) or pressing (discs). The parts are then fired at a temperature high enough to sinter the constituent oxide. The final step is the making of the electrical contacts. This is done in the usual way by burning in with silver paste or by other methods e.g. electroplating or metal spraying.

Miniature NTC thermistors are made by applying a drop of oxide paste between two parallel platinum alloy wires, followed by drying and sintering. The platinum alloy wires are 60 μm in diameter and 0.25 mm apart. By the sintering process the bead is shrunk onto the wires, thus establishing a solid and reliable contact. For most applications the miniature NTC thermistors are mounted in glass for protection against influence by aggressive gases and fluids.

$\propto$ = direct proportional to.

ELECTRICAL PROPERTIES

RESISTANCE VERSUS TEMPERATURE CHARACTERISTICS

As is shown in the introduction the relation between resistance and temperature of an NTC thermistor can be approximated by:

$$R = Ae^{B/T}, \qquad (1)$$

where R is the resistance value at an absolute temperature T, A and B being constants for a given resistor and e the base of the natural logarithm (e = 2.718). This equation is illustrated in Fig. 1 where R has been plotted against the temperature in °C.
This is quite in contrast with the behaviour of metals, with which in first approximation the resistance increases proportionally to the absolute temperature.

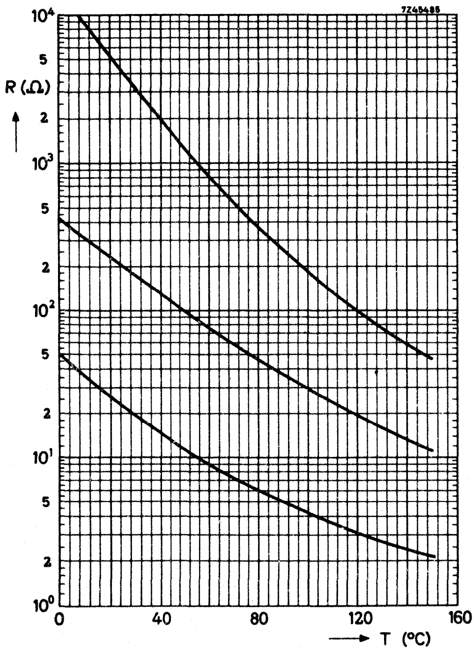


Fig. 1.
Resistance R as a function of temperature drawn for three different values of A and B.

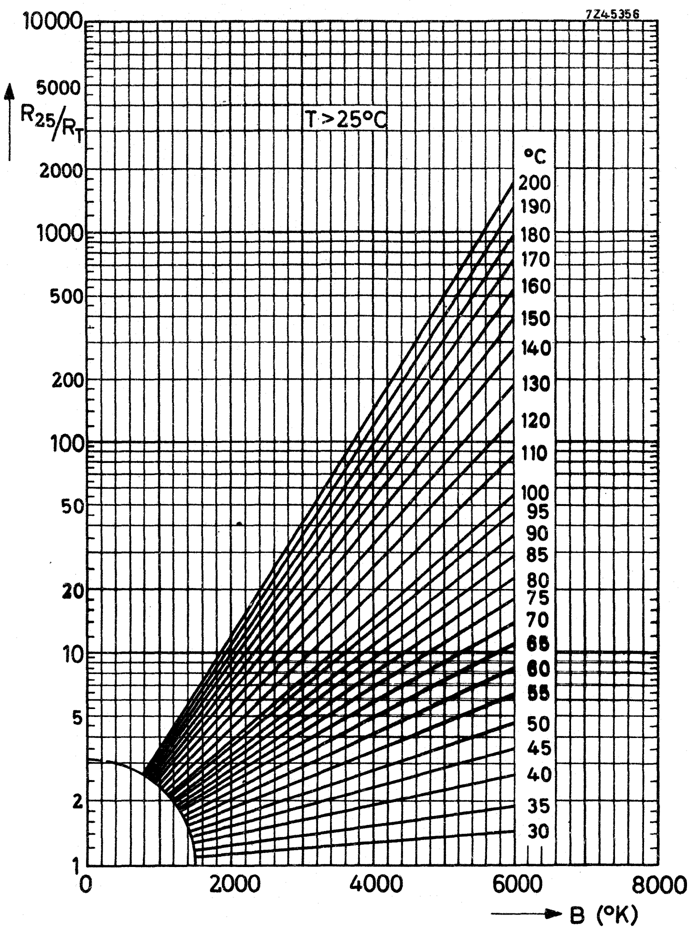


Fig.2.
R_{25}/R_T as a function of the B-value with the temperature as a parameter.
Temperatures above 25 °C.

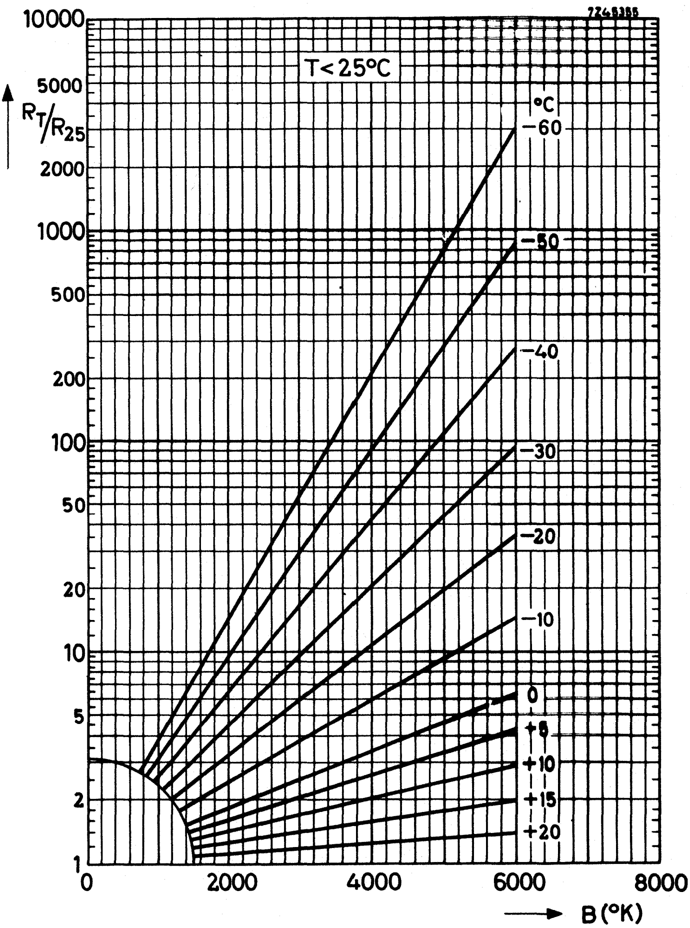


Fig.3.
R_T/R_{25} as a function of the B-value with the temperature as a parameter.
Temperatures below 25 °C.

For a given NTC thermistor the value of B may be found in the following way. The resistance value is measured at two temperatures, T_1 and T_2,

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

dividing these two, yields:

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

or:

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

which gives:

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

In practice B is found not to be a true constant; with increasing temperature there are small deviations.
A better formula for the resistance value is:

$$R = AT^{C}e^{B/T},$$

where C is a small positive or negative number and in some cases is zero. 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 $^{\circ}$K. A value of e.g. 3600 yields $\alpha = -4\%$ per degree at a temperature of 300 $^{\circ}$K.
For calculating the resistance of an NTC at a given temperature, when R_{25} and B are given in the data, the graphs of Fig. 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.

VOLTAGE VERSUS CURRENT CHARACTERISTICS

It is interesting to investigate the relation 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. Fig.4 shows this relation for an arbitrary sample. This so-called static characteristic, plotted on a double logarithmic scale, was measured at a constant ambient temperature and the readings of V were taken after equilibrium had been reached. For very small currents, the power consumption is too small to register a distinct rise in temperature or

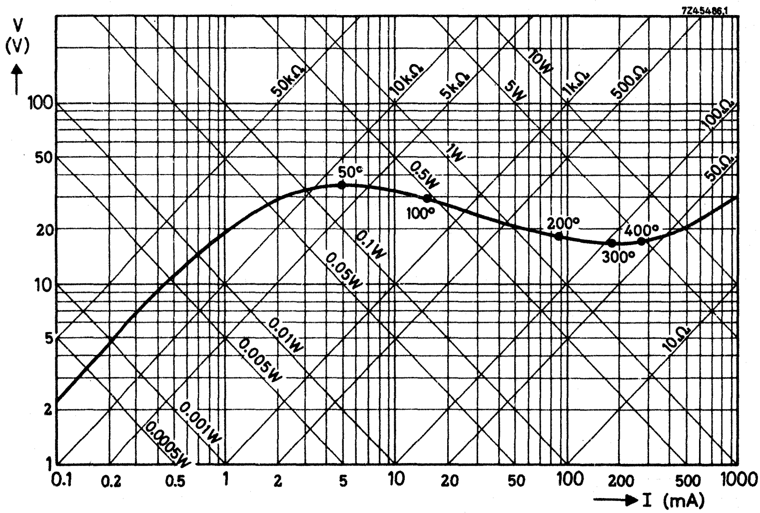


Fig.4. Voltage versus current characteristics of an NTC thermistor.

a decrease in resistance. In that part of the characteristic the relationship between voltage and current is linear. For the sample chosen this linearity ends at approximately 0.01 W.
At a certain value of I the voltage reaches a maximum value and will decrease as the current increases still further.

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)

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

the following may be written:

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

In case of equilibrium

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

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

From eqs (5) and (4) follows:

$$\log_e V + \log_e I = \log_e \delta + \log_e (T - T_o), \qquad (6)$$

$$\log_e V - \log_e I = \log_e A + B/T. \qquad (7)$$

Combination of these two yields:

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

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

$$\frac{d \log_e V}{dT} = 0. \qquad (9)$$

In that case

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

which is true only for those values of T which answer to the equation:

$$T^2 - BT + BT_o = 0, \qquad (11)$$

$$T_{max} = \tfrac{1}{2}B \pm \sqrt{\tfrac{1}{4}B^2 - BT_o}\,. \qquad (12)$$

(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 stationary circumstances 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 °C in temperature (unit J/°C).

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/°C).

The thermal time constant represents 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 change in temperature.

H is completely determined by the component design. The thermal time constant depends on δ which is different when measured in different media.

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

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

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

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

in which T_o is the ambient temperature.

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

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

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

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

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

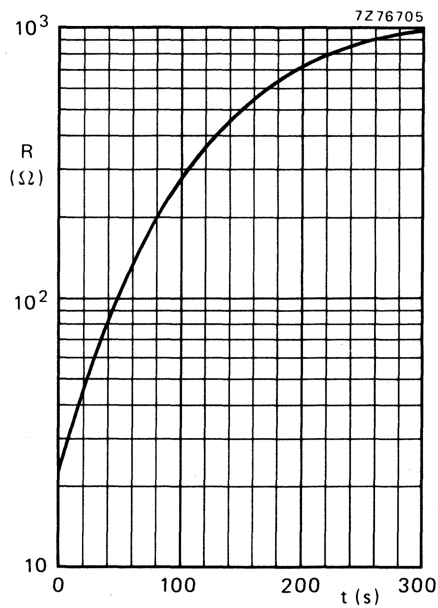


Fig.5 Variation of resistance with time under normal cooling conditions of a rod type NTC. Ambient temperature 25 °C.

HOW TO MEASURE NTC THERMISTORS

(1) The published R_T values are measured at the temperature T.

(2) 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:

(1) Never measure thermistors in air as this is quite inaccurate and easily gives deviations of 1 or 2 °C. 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.

(2) Use a thermostat with a precision 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.

(3) 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.

(4) Keep the measuring voltage as low as possible otherwise the NTC will be heated by the measuring current. Miniature NTC thermistors are specially sensitive to measuring voltages. Voltages of less than 0.5 V are recommended.

(5) For high temperature measurements it is recommended to apply stem correction. See also "How to measure PTC thermistors".

SPREAD

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

The R_{25} and B-value are specified with a certain spread. The tolerance on 25 °C resistance is normally specified as ±10% or ±20%. The B-value has in most cases a tolerance of ±5%. Due to the spread in B-value, the deviation from the nominal curve at other temperatures than 25 °C can be greater than the specified tolerance at 25 °C (Fig.6).

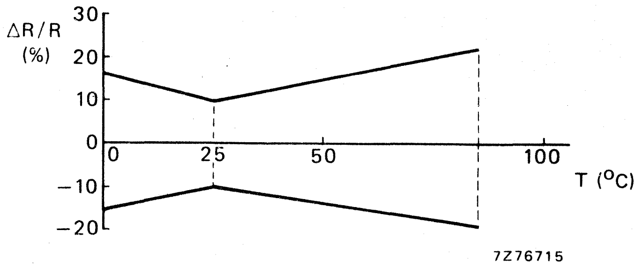


Fig.6

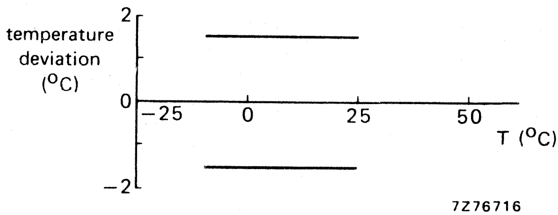


Fig.7

Resistance specified at more than one temperature

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 is of less influence because it is included in the tolerance at the specified points. For several types the tolerance is given on the resistance values at 2 or 3 temperatures, for other types (e.g. NTC thermistors for deep-freezers) the tolerance is given on the temperatures corresponding with 2 resistance values of a thermistor (Fig.7).

CHOICE OF TYPE

For selection of an NTC thermistor the following characteristics should be considered primarily:

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

Whenever 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, with simple parallel and series resistors, a standard NTC can be used 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. In addition 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 is wanted with a resistance value 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.8, the resistance of the combination at 30 °C and at 100 °C will meet the requirements. Fig.9 shows the new resistance versus temperature graph, together with that of the NTC thermistor.

An adaption of this kind should be calculated for every individual case. It should be remembered of course that the temperature coefficient of the combination will always be lower than that of the NTC thermistor alone. This is clearly illustrated by Fig.10, where the change in the resistance/temperature graph is shown for different values of series and parallel resistors.

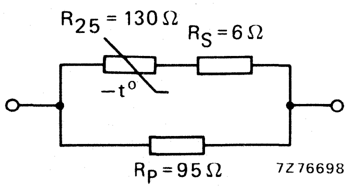


Fig.8 NTC thermistor connected in series and parallel with two fixed resistors to obtain deviating characteristics.

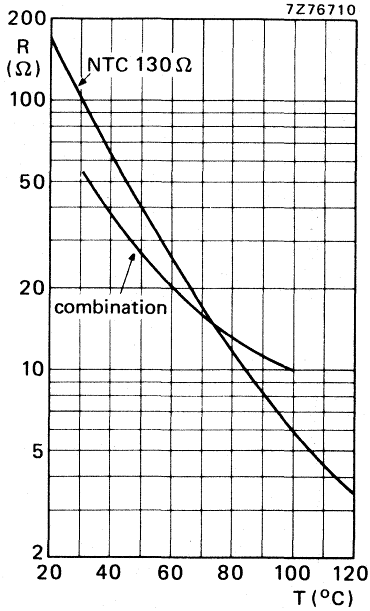


Fig.9 Resistance versus temperature graph of the circuit of Fig.8.

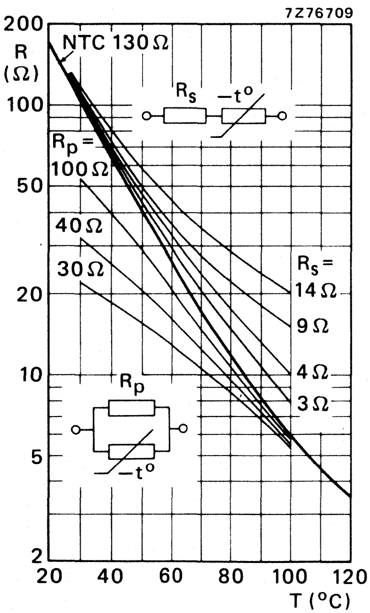


Fig.10 Resistance versus temperature graphs of an NTC in combination with different series or parallel resistors.

SOLDERING DISC NTC THERMISTORS

It is often necessary to solder mounting brackets or connecting leads to disc NTCs either to provide efficient thermal contact or to facilitate their mounting. Owing to the ceramic nature of the thermistor and its silver coating, special precautions must be taken to ensure a satisfactory joint.
The iron, its temperature, the solder and flux as well as the material of the bracket all affect the result.

The soldering iron

This should have a wedge-shaped copper bit with an angle of 30^o to 45^o. Before use, and when necessary during use, it should be cleaned and tinned with the solder recommended below. It is most important that the bit temperature is maintained between 275 ^oC and 300 ^oC. A means of measuring and controlling this temperature is considered necessary.

The solder

To prevent migration of the silver coating of the thermistor into the solder and eventual failure of the joint, a silver-rich solder should be used. A satisfactory composition is 56% tin, 37% lead and 7% silver, without a resin core.

The flux

The correct iron temperature and an approved flux are the two most important factors in this process. It is recommended that a flux of the following composition be used:

1 kg colophonium
100 g urea
1500 ml ethyl alcohol 98%.

The bracket or wire

Tinned copper wire is satisfactory but the end should be bent into a loop. It is best to avoid sizes heavier than 0,5 mm. Brackets should be electro-tinned copper not more than 3 mm thick. A hole, preferably star-shaped and about 3 mm diameter, in the bracket should coincide with the centre of the thermistor disc.

The process

The whole face of the thermistor should be coated with special flux and the bracket or wire held in position. About a 6 mm length of solder is melted onto the iron and transferred to the joint so that the solder flows over the bracket onto the thermistor. The soldering time should be kept as short as possible. Preheating of the thermistor on a hot plate at 80 °C to 100 °C helps to ensure rapid and reliable soldering. The soldering must be completed before the flux hardens.
Unless this process is followed, it is not possible to ensure entirely satisfactory results (and no responsibility can be taken for failures).

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.

REMARKS ON THE USE OF NTC THERMISTORS

Do not use thermistors in parallel to obtain a higher dissipation as one of the thermistors may heat up and take all the current while the others remain cold.

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

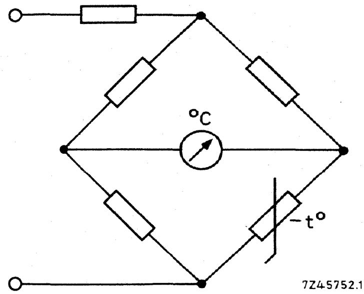
For temperature measurements do not use a too high voltage on the NTC thermistor as it may heat-up the thermistor, thus giving incorrect readings.
The dissipation constant is an indication for the maximum permissible measuring power.

Do not solder-on NTC discs without consulting the soldering instructions.

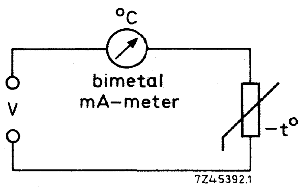
Some of the more familiar application circuits in the entertainment and industrial field are given on the following pages.

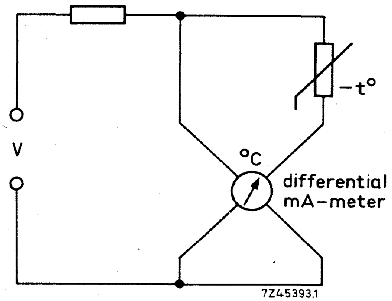
APPLICATION EXAMPLES

Temperature measurement.
Industrial and medical thermometers.

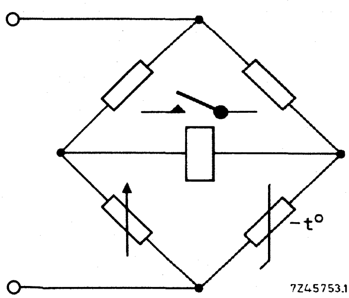


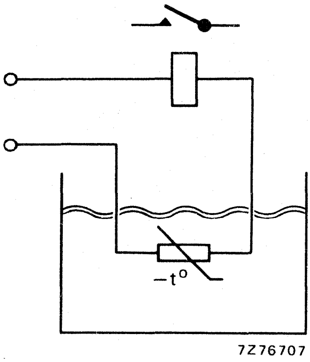
Temperature measurement in cars.
Cooling water measurements with
bimetal or differential milliammeters.



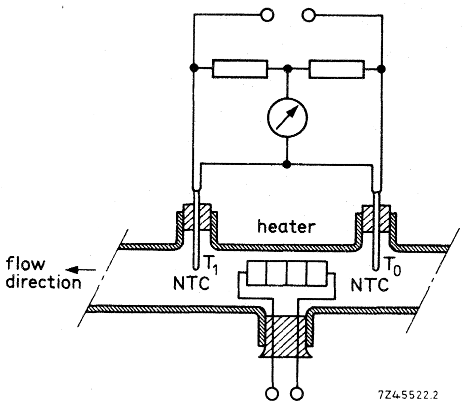


Temperature control with a bridge
incorporating an NTC thermistor
and a relay or a static switching
device.

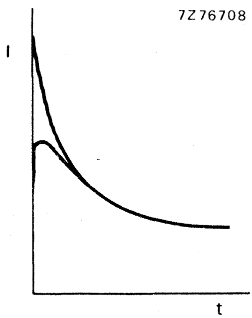


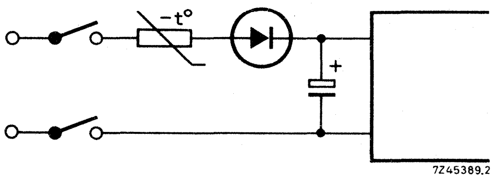


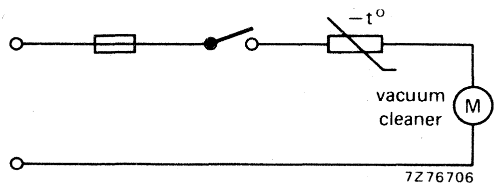
Liquid level control



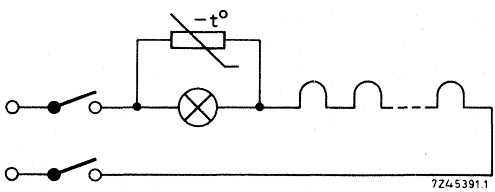
Flow measurement of liquids. The temperature difference between T_1 and T_0 is a measure for the velocity of the fluid.





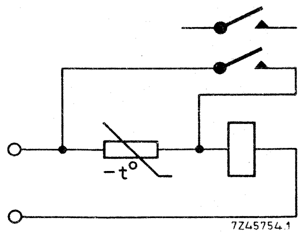


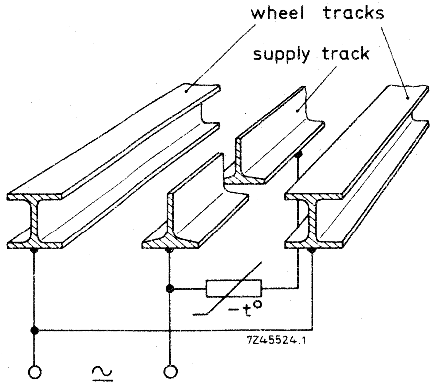
Inrush current limiter, e.g. for protection of Si-diodes, fuses and switches.



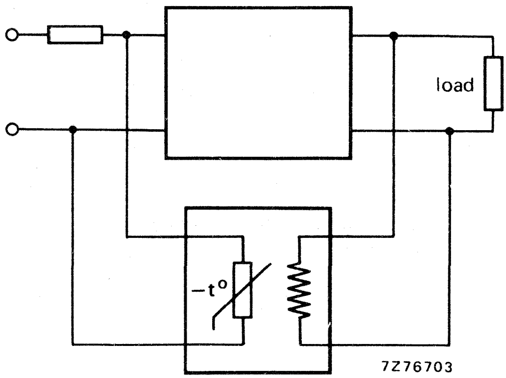
Shunt of dial lamps. If the dial lamp fails the NTC becomes low ohmic and the heater chain is not disconnected.

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.

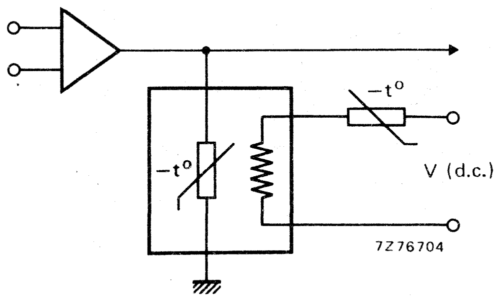




Model trains. As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

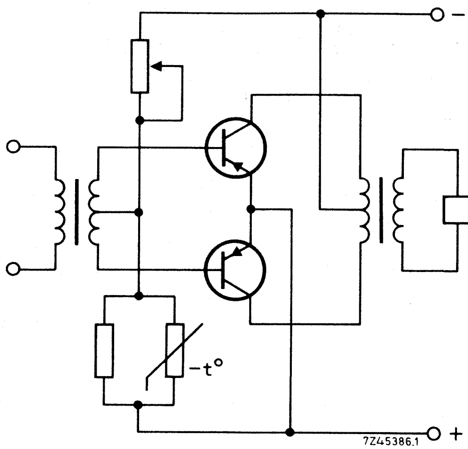


Gain compensation or gain control with an indirectly heated NTC.

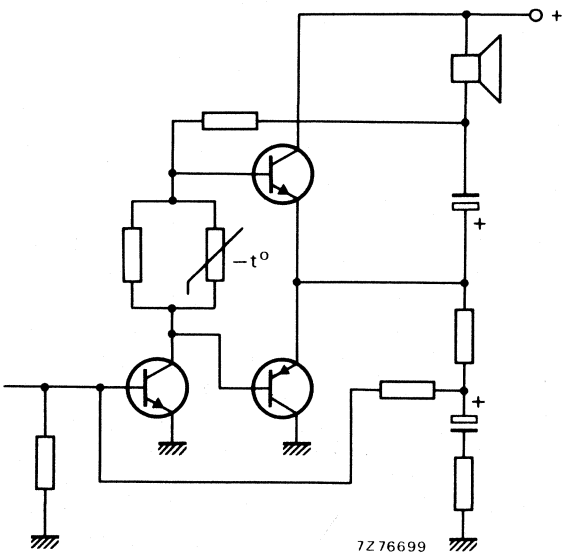


Compensation for the influence of ambient temperature variations in an h.f. amplifier.

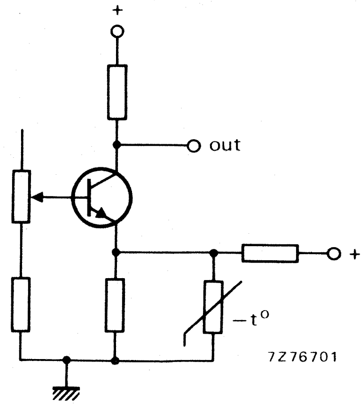
Temperature compensation in transistor circuits. Push-pull compensation.



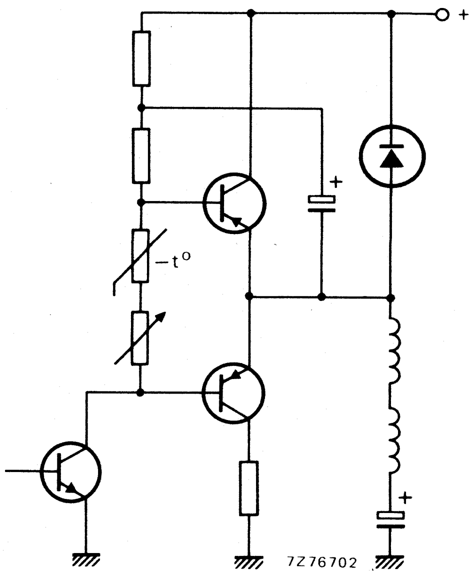
Transformerless audio output stage with temperature compensation.



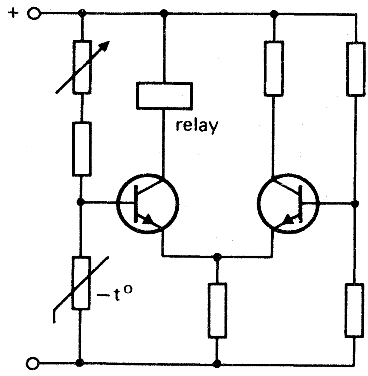
Stabilization with temperature of an a.g.c. amplifier in a television set.



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.

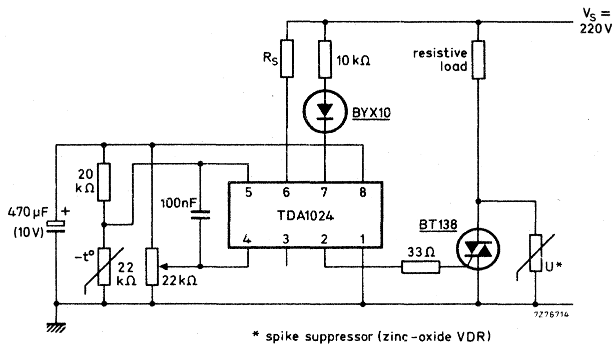


Simple thermostat.



Thermostat for room heating with a 2-point NTC thermistor as the sensing element.

(For complete information, see our Technical Informations 010 and 025).



* spike suppressor (zinc-oxide VDR)

NTC THERMISTORS
disc without leads

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
Operating temperature range	
at zero power	-25 to +125 °C
at maximum power	0 to +55 °C

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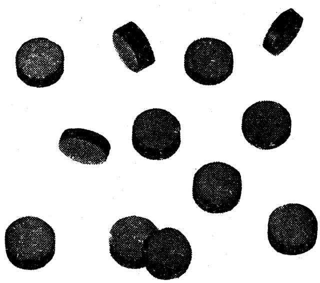

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

This leadless disc is not lacquered nor insulated.

MECHANICAL DATA

Dimensions in mm

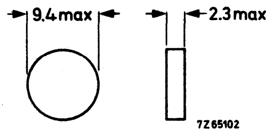

Fig. 1

Marking

The resistance value and tolerance are printed on one face of the thermistor body according to the Table below.
Actually both EKM and IEC 62 marking systems are used for marking these NTC thermistors. The IEC 62 system will progressively supersede the EKM system which will be cancelled.
Tolerance indication:

a) In the EKM marking system, devices with a tolerance of ± 20 % have no tolerance letter. Devices with a tolerance of ± 10 % are marked with a letter A preceding the resistance value.

b) In the IEC marking system, both tolerances are indicated by a letter placed after the resistance value. This letter is K in case of a tolerance of ± 10 % and M in case of a tolerance of ± 20 %.

Weight

0.6 to 0.8 g.

Mounting

In any position between clamps or with the aid of leads soldered to the faces.

Soldering

For complete soldering recommendations see relevant paragraph in section "NTC thermistors, general".

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

ELECTRICAL DATA

R_{25} Ω	$B_{25/85}$ ±5% K	temperature coefficient %/°C	marking EKM system	 IEC 62 system	catalogue number 2322 610 0.... tol. ±20%	 tol. ±10%
1,1	2600	−2,90	1E1	1R1	1118	2118 ←
2,2	2675	−3,00	2E2	2R2	1228	2228
4	2800	−3,15	4E	4R0	1408	2408
6	2825	−3,15	6E	6R0	1608	2608
8	2900	−3,25	8E	8R0	1808	2808
10	2950	−3,30	10E	10R	1109	2109
12	3050	−3,40	12E	12R	1129	2129
15	3000	−3,40	15E	15R	1159	2159
33	3250	−3,65	33E	33R	1339	2339
50	3300	−3,70	50E	50R	1509	2509
82	4400	−4,95	82E	82R	1829	2829
130	4600	−5,15	130E	130R	1131	2131
500	5200	−5,85	500E	500R	1501	2501
1300	5450	−6,15	1K3	1K3	1132	2132

Maximum dissipation 1 W *

Operating temperature range
- at zero power −25 to +125 °C
- at maximum power 0 to +55 °C

* Measurements made in still air.

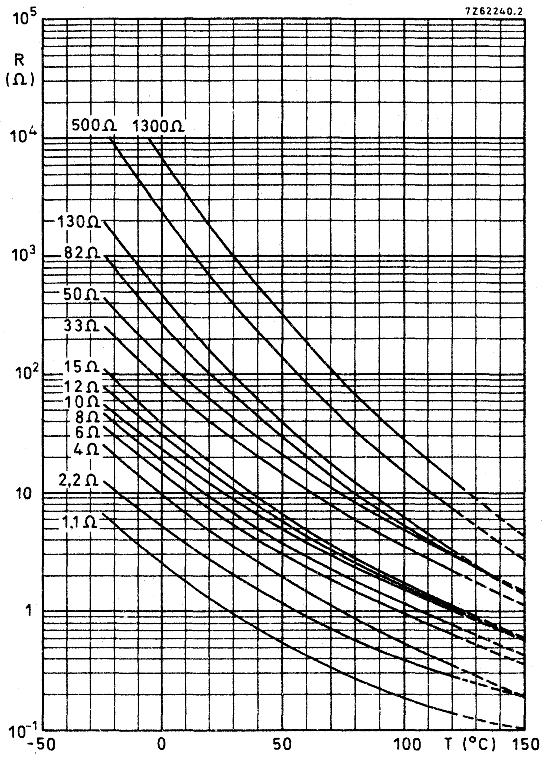

Fig.2 Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified:

test	test method	duration	ΔR/R(%) at 25 °C	ΔB/B(%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat, + 125 °C	B	1000h	± 5	± 2
Thermal shock - 25 to + 125 °C	Na	5 cycles	± 3	± 2
Damp heat	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Soldering	T			
Solderability at 230 ± 10 °C	par. 3. 2. 3	3 to 4 s	1)	1)
Resistance to heat at 230 ± 10 °C	par. 3. 2. 4	3 to 4 s	± 2	± 2

1) Thermistors must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1% major defects - Electrical

A.Q.L. 1.5% major defects - Mechanical

A.Q.L. 4% minor defects - Physical

PACKAGING

250 pieces per box (cardboard).

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/°C
Thermal time constant	60 s approx.
Operating temperature range	
at zero power	-25 to + 125 °C
at maximum power	0 to +55 °C

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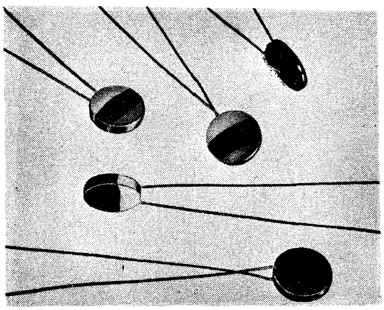


APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

These thermistors consist of a disc provided with two solid tinned copper wires and with a colour code on the non-lacquered, non-insulated body.

MECHANICAL DATA

Dimensions in mm

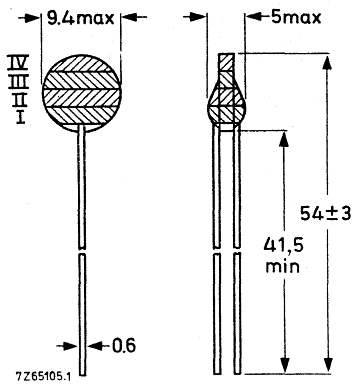


Fig. 1

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.

Weight

1.0 to 1.3 g

Mounting

In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

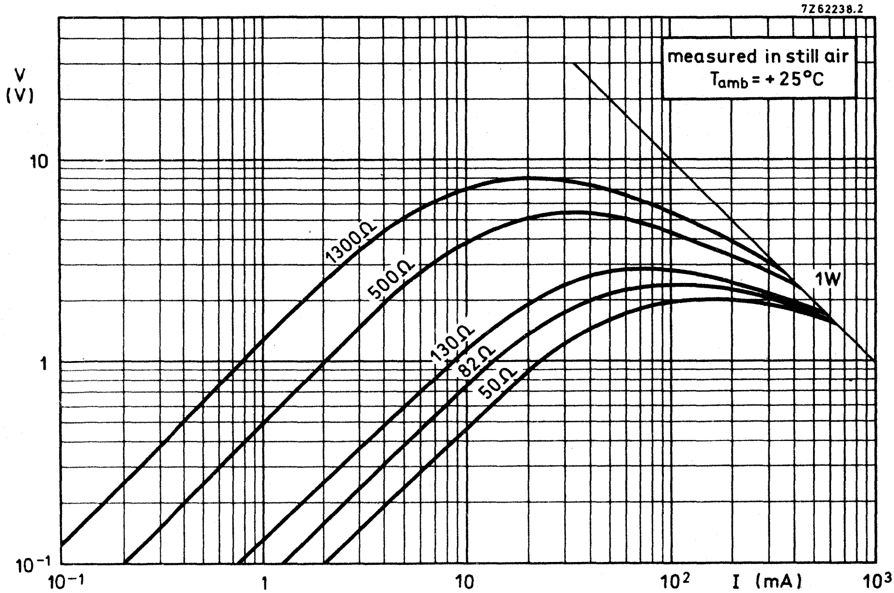
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 240 °C, max. 4 s

ELECTRICAL DATA

R25	B25/85 ± 5%	temperature coefficient	colour code			catalogue number 2322 610 1.....	
			I	II	II		
Ω	K	%/°C				tol. ±10%	tol. ±20%
1,1	2600	-2,90	brown	brown	gold	2118	1118 ←
2,2	2675	-3,00	red	red	gold	2228	1228
4	2800	-3,15	yellow	black	gold	2408	1408
6	2825	-3,15	blue	black	gold	2608	1608
8	2900	-3,25	grey	black	gold	2808	1808
10	2950	-3,30	brown	black	black	2109	1109
12	3050	-3,40	brown	red	black	2129	1129
15	3125	-3,50	brown	green	black	2159	1159
33	3250	-3,65	orange	orange	black	2339	1339
50	3300	-3,70	green	black	black	2509	1509
82	4400	-4,95	grey	red	black	2829	1829
130	4600	-5,15	brown	orange	brown	2131	1131
500	5200	-5,85	green	black	brown	2501	1501
1300	5450	-6,15	brown	orange	red	2132	1132

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

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



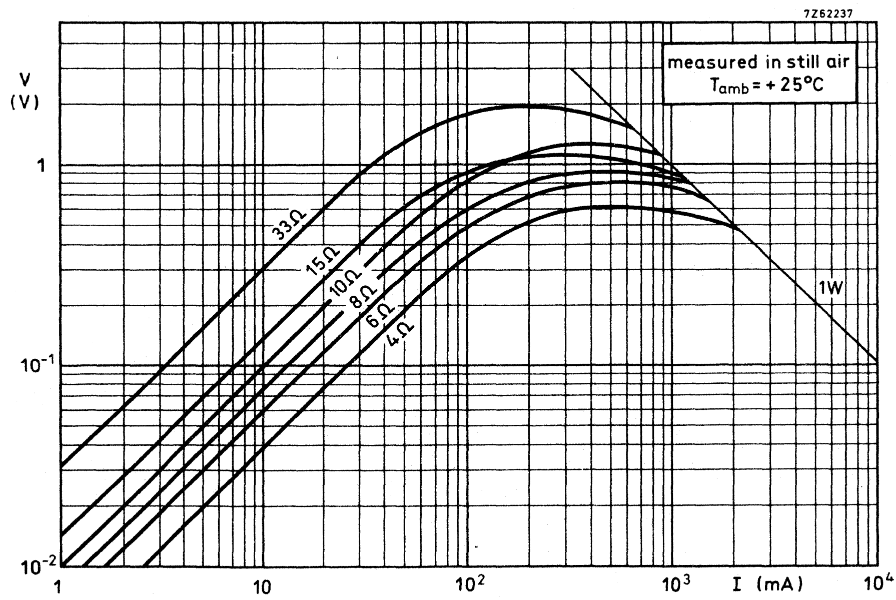


Fig. 2a and b. Typical voltage/current characteristics.

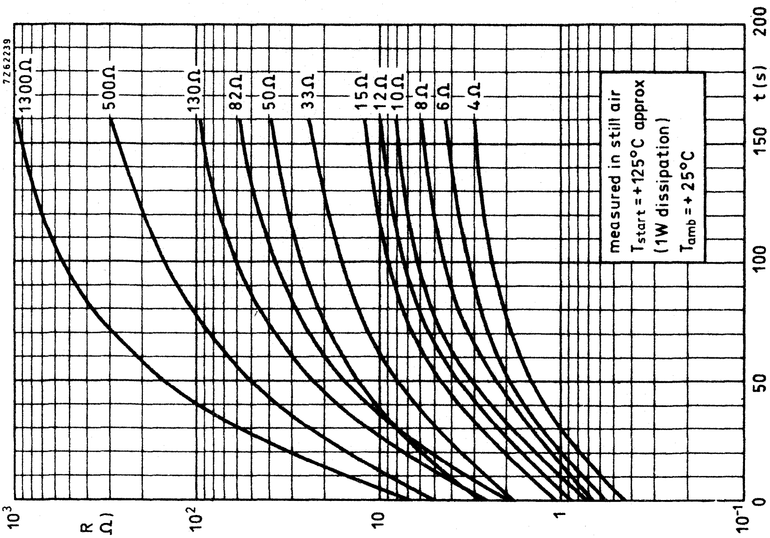


Fig. 4. Typical resistance/time (cooling) characteristics

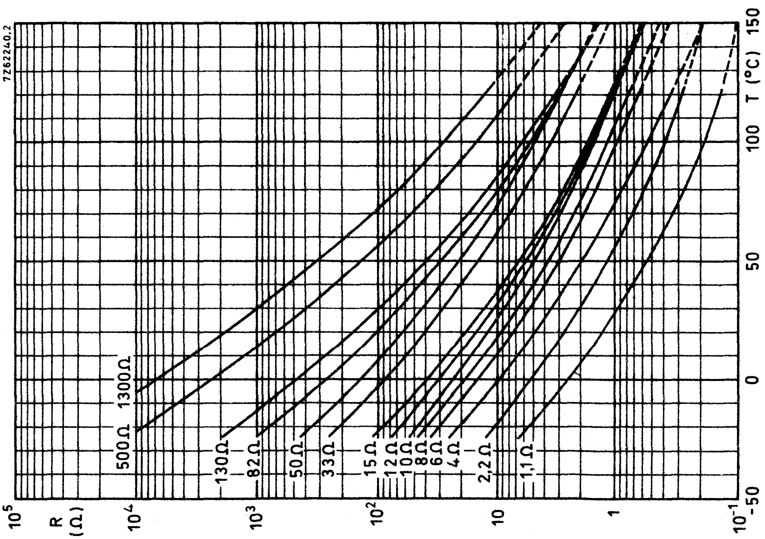


Fig. 3. Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25°C	ΔB/B (%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat at + 125 °C	B	1000h	± 5	± 2
Thermal shock -25 to +125 °C	Na	5 cycles	± 3	± 2
Damp heat	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 ± 10 °C	par 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1% major defects - Electrical
A.Q.L. 1.5% major defects - Mechanical
A.Q.L. 4% minor defects - Physical

PACKAGING

250 pieces per box (cardboard)

NTC THERMISTORS
disc on metal strip

QUICK REFERENCE DATA	
Resistance values at +25 °C	4 to 1300 Ω
$B_{25/85}$ values	2800 to 5450 °K
Maximum dissipation	1 W
Operating temperature range	
at zero power	-25 to + 125 °C
at maximum power	0 to + 55 °C

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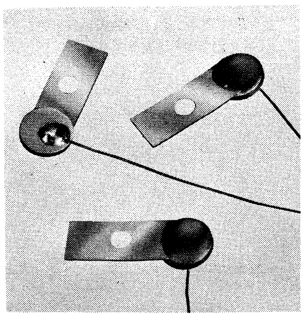


APPLICATION
Suitable for all kinds of applications.

DESCRIPTION
These thermistors consist of a disc with one solid tinned copper lead and a metal stripat an angle of 90° with the lead. The body is not lacquered nor insulated.

MECHANICAL DATA

Dimensions in mm

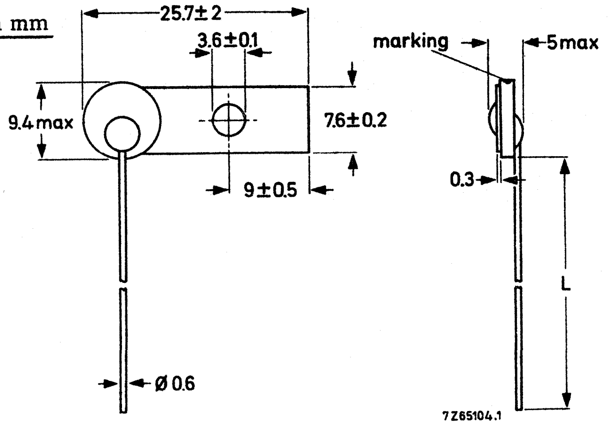


Fig.1

Marking / Weight

marking	L_{min} (mm)	weight approx. (g)	catalogue number
none	**41,6**	1,40	2322 610 90004
red dot	**56,6**	1,40	90012
orange dot	**41,6**	1,60	90014
violet dot	**56,6**	1,60	90015
yellow dot	**41,6**	1,60	90016
green dot	**41,6**	1,60	90017
blue dot	**41,6**	1,60	90018

Mounting

In any position with nut and bolt; lead connected by soldering.

Robustness of terminations

Tensile strength	10 N	(strip and lead)
Torsion	5 N	(strip and lead)

Soldering (for lead only)

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

ELECTRICAL DATA

R_{25} ± 20% (Ω)	$B_{25/85}$ ± 5% (°K)	temperature coefficient (%/degC)	catalogue number
4	2800	-3, 2	2322 610 90012
6	2825	-3, 2	90014
8	2900	-3, 3	90015
50	3300	-3, 7	90016
130	4600	-5, 2	90004
500	5200	-5, 9	90017
1300	5450	-6, 2	90018

Maximum dissipation at +55 °C — 1 W [1)]

Operating temperature range
- at zero power — -25 to +125 °C
- at maximum power — 0 to +55 °C

1) Measurements made in still air, between two phosphor-bronze wires (ø 1.3mm).

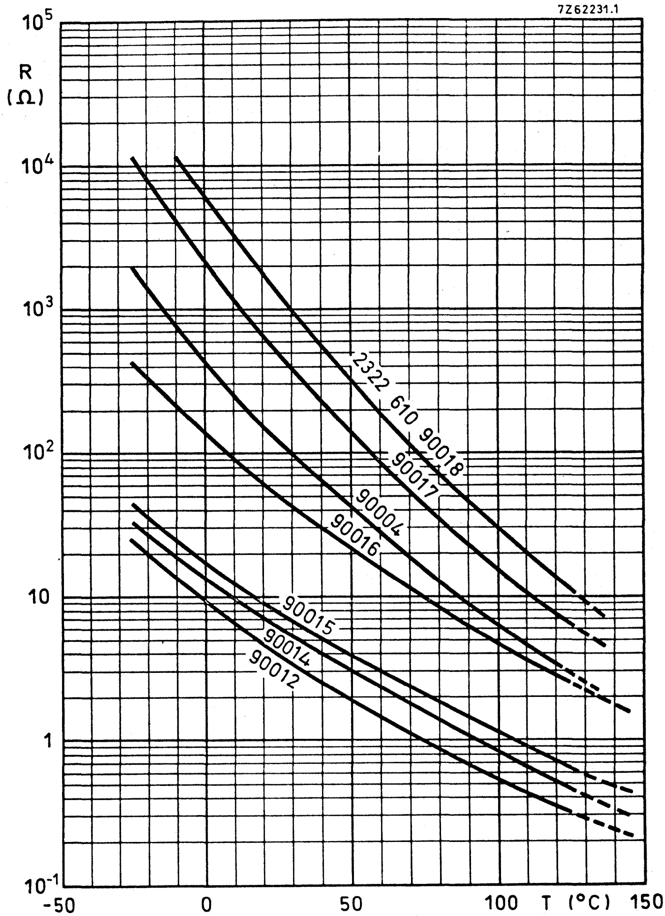


Fig. 2 Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at + 25°C	ΔB/B(%)
Cold at - 25 °C	A	1000h	± 3	± 2
Storage at + 25 °C	H	1000h	± 3	± 1
Dry heat at +125 °C	B	1000h	± 5	± 2
Thermal shock -25 to +125 °C	Na	5 cycles	± 3	± 2
Damp heat at +55 °C	Ca	1000h	± 5	± 3
Maximum dissipation		1000h	± 5	± 2
Robustness of terminations	U			
Tensile strength ION	Ua	10 s	1)	
Bending 5N, lead	Ub	2 times		
strip		3 times	1)	
Soldering	T			
Solderability at 230 ± 10°C	par. 3. 2. 3	3 to 4 s	2)	
Resistance to heat at 230 ± 10 °C	par. 3. 2. 4	3 to 4 s	± 2	± 2

1) Lead or strip should neither come loose nor break.
2) Lead must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1% major defects - Electrical

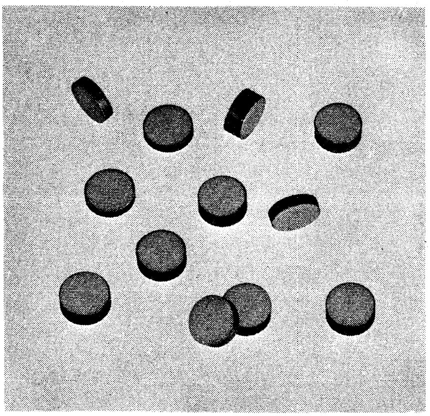
A.Q.L. 1.5% major defects - Mechanical

A.Q.L. 4% minor defects - Physical

PACKAGING

250 pieces per box (cardboard)

NTC THERMISTORS
for motor cars

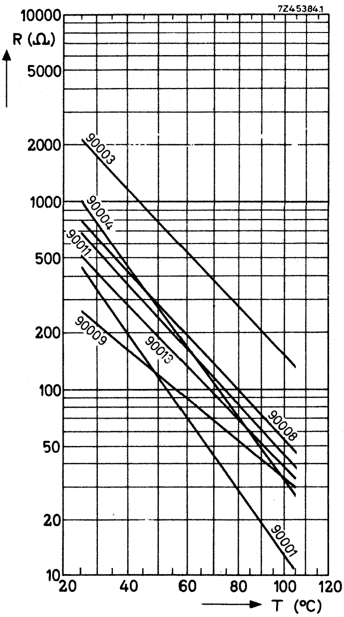


RZ 19269-3

This range of discs has been developed for temperature sensors for the cooling water in motor cars. The NTC's are specified at a medium temperature (40-50 °C) and a higher temperature (96.5 to 100 °C), so that a high accuracy at the working temperature is obtained.
They are also suitable for temperature control in household appliances, such as washing machines.

R_{25} (Ω)	R_{40} (Ω)	R_{50} (Ω)	$R_{96.5}$ (Ω)	R_{100} (Ω)	diameter (mm)	catalog 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

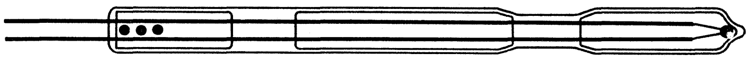
Resistance/temperature characteristics



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/°C
Thermal time constant	14 s
Operating temperature range	
at zero power	-25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

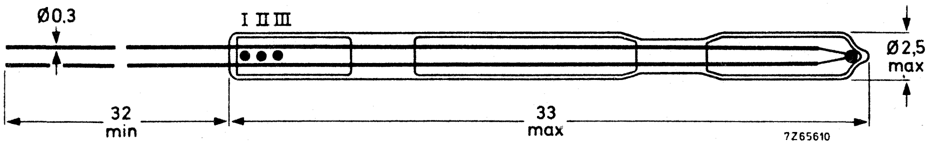
Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



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

Marking

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

Mass

0,3 g approx.

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

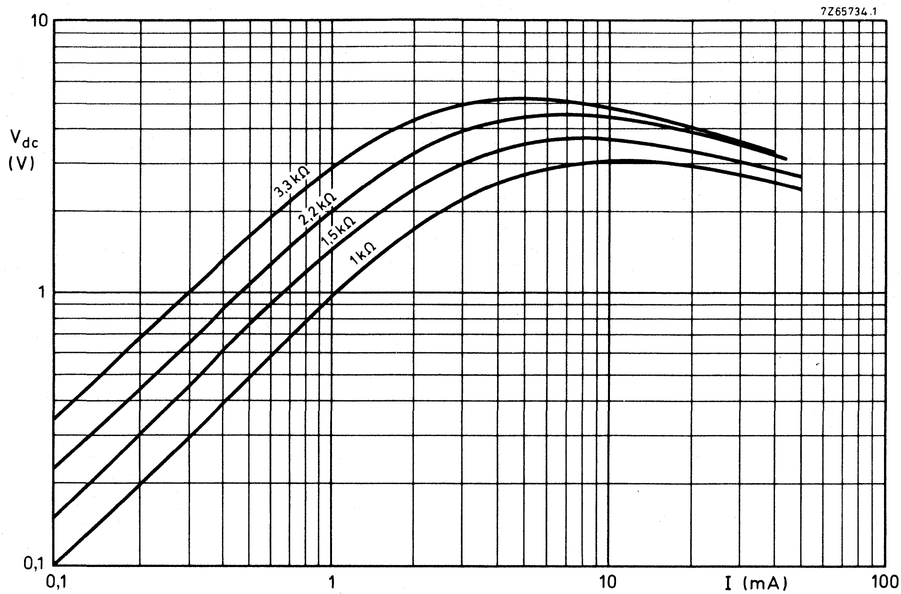
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

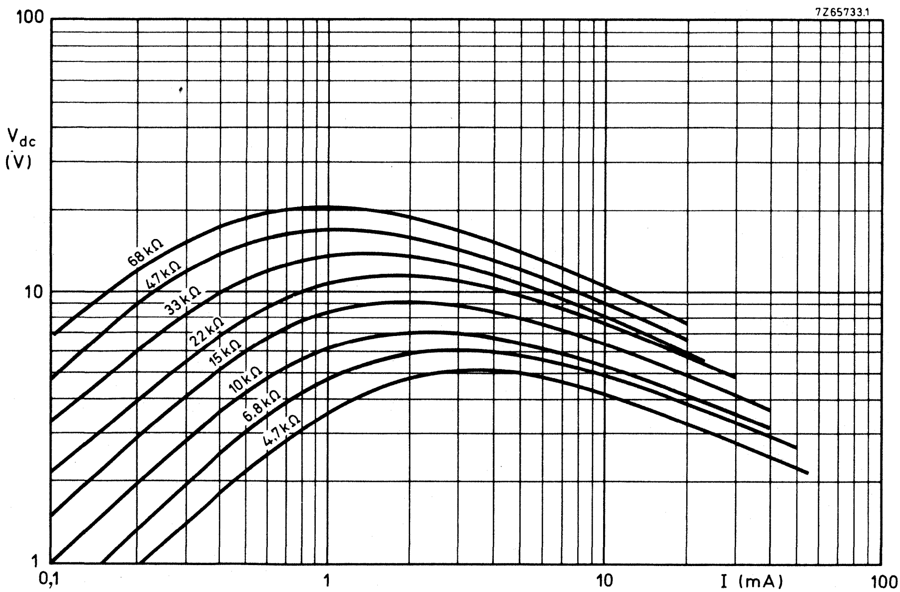
R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/°C	colour code * I	II	III	catalogue number 2322 627 1.... tol. ± 10% *	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3800	−4,3	brown	black	yellow	2104	1104
150000	3880	−4,4	brown	green	yellow	2154	1154
220000	3920	−4,4	red	red	yellow	2224	1224
330000	3980	−4,5	orange	orange	yellow	2334	1334
470000	4030	−4,5	yellow	violet	yellow	2474	1474
680000	4100	−4,6	blue	grey	yellow	2684	1684

* Only for 10% tolerance a silver dot is added to the colour code.

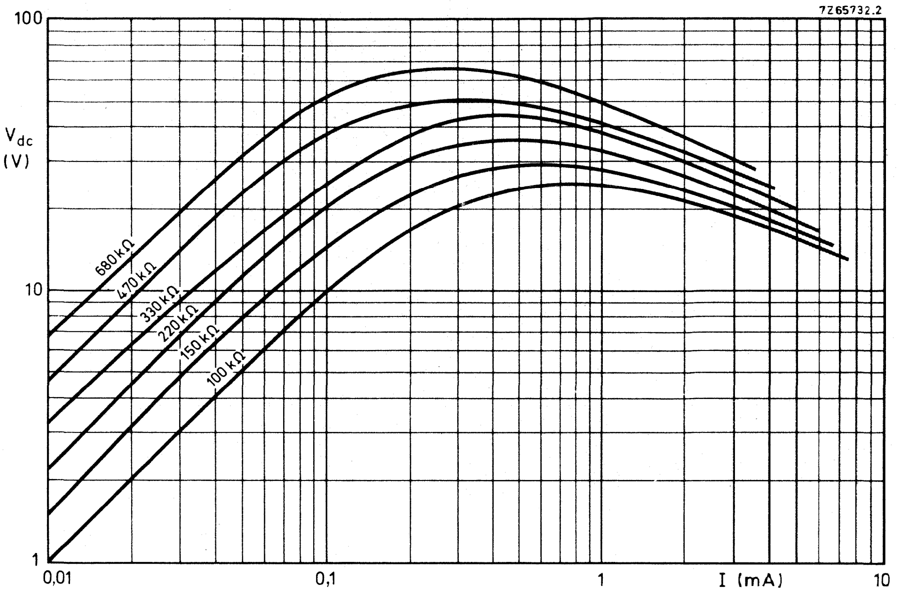
Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/°C approx.
Thermal time constant	14 s approx.
Heat capacity of ceramic	0,5 . 10^{-3} J/°C approx.
of complete component	9,8 . 10^{-3} J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C
Dielectric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



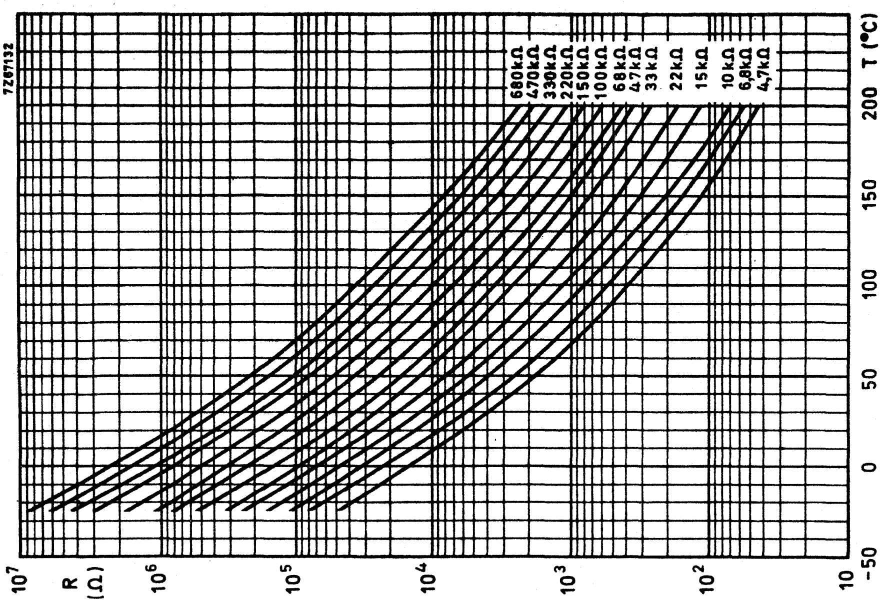
Typical voltage/current characteristics.



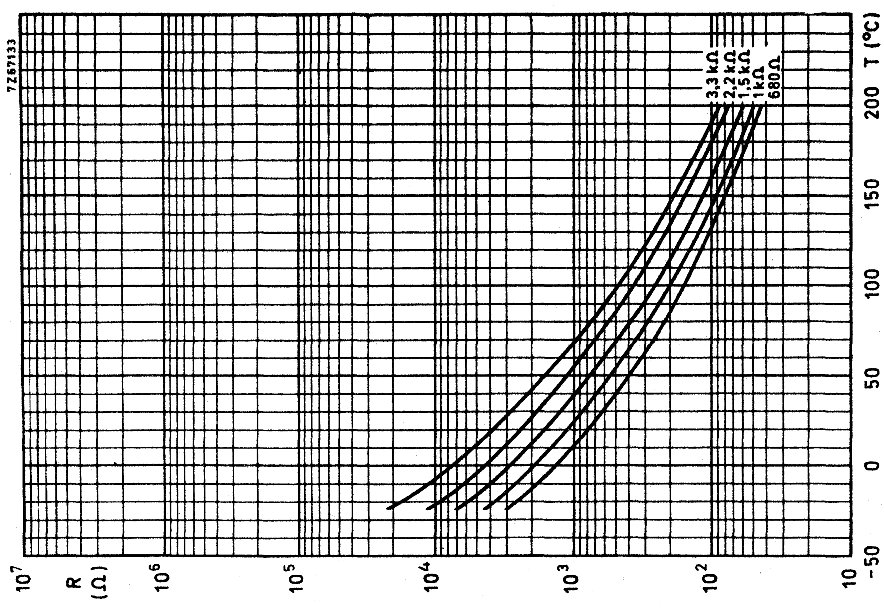
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendation unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 2	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	–
Bending 1, 25 N	Ub	2 times	1)	–
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	2)	–
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

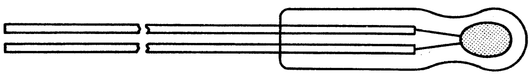
PACKAGING

100 pieces per box (cardboard)

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/°C
Thermal time constant	10 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

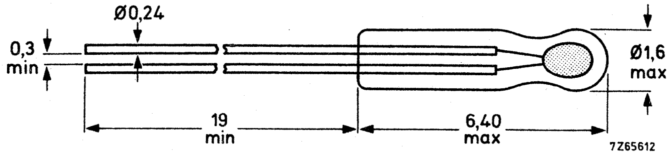
Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

None

Mass

0,03 g approx.

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

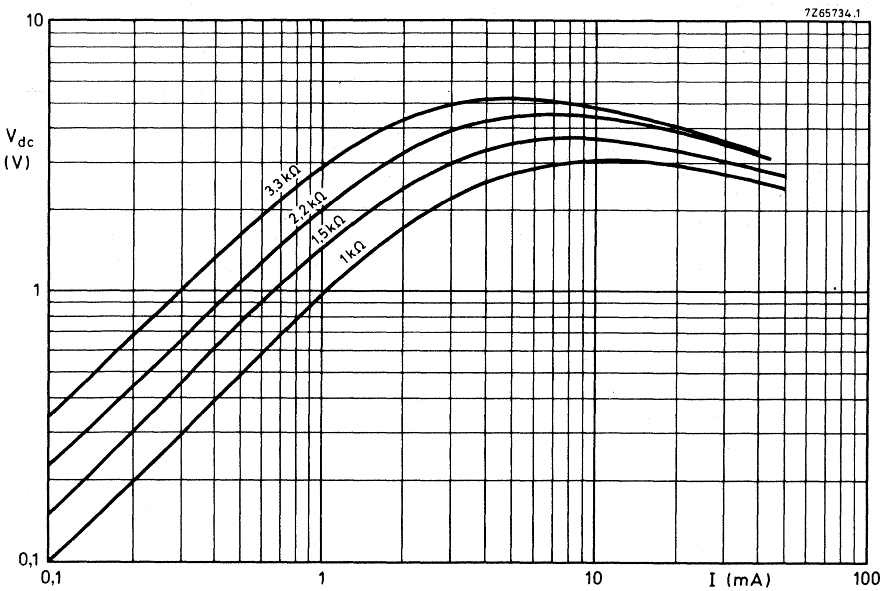
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

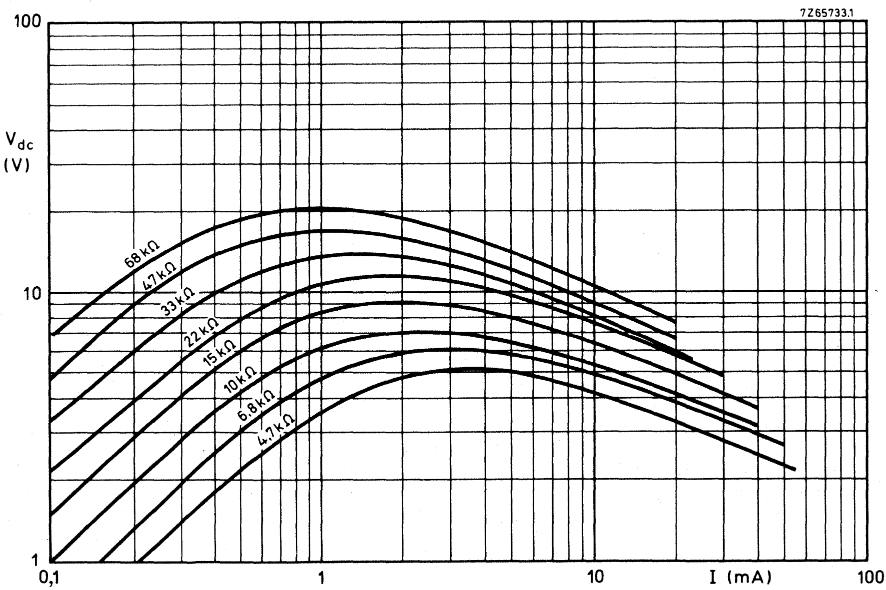
R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/°C	catalogue number 2322 627 2.... tol. 10%	tol. 20%
680	2200 *	−2,5	2681	1681
1000	2375 *	−2,7	2102	1102
1500	2500 *	−2,8	2152	1152
2200	2600 *	−2,9	2222	1222
3300	2750 *	−3,1	2332	1332
4700	3725	−4,2	2472	1472
6800	3775	−4,3	2682	1682
10000	3875	−4,3	2103	1103
15000	3800	−4,3	2153	1153
22000	3850	−4,3	2223	1223
33000	3800	−4,3	2333	1333
47000	3850	−4,3	2473	1473
68000	3900	−4,4	2683	1683
100000	3800	−4,3	2104	1104
150000	3880	−4,4	2154	1154
220000	3920	−4,4	2224	1224
330000	3980	−4,5	2334	1334
470000	4030	−4,5	2474	1474
680000	4100	−4,6	2684	1684

* For these types the tolerance on B-value is ± 10% instead of ± 5%.

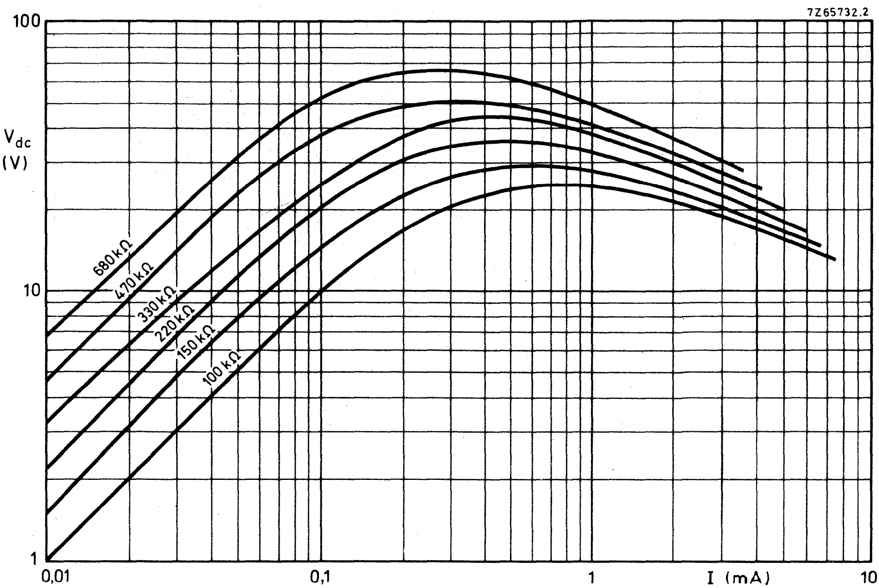
Maximum dissipation at +55 °C	100 mW
Dissipation factor	0,7 mW/°C approx.
Thermal time constant	10 s approx.
Heat capacity of ceramic	$0,5 \cdot 10^{-3}$ J/°C approx.
of complete component	$7,0 \cdot 10^{-3}$ J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to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



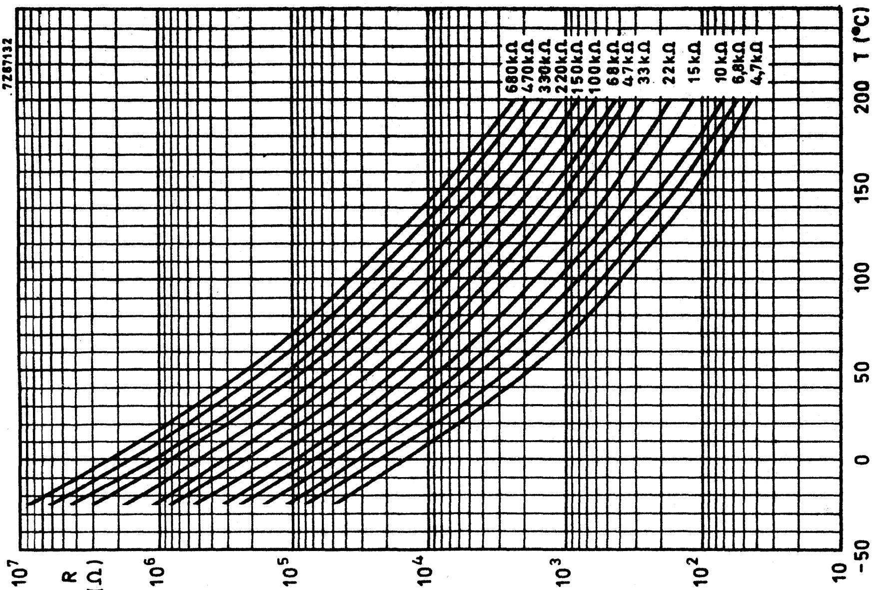
Typical voltage/current characteristics.



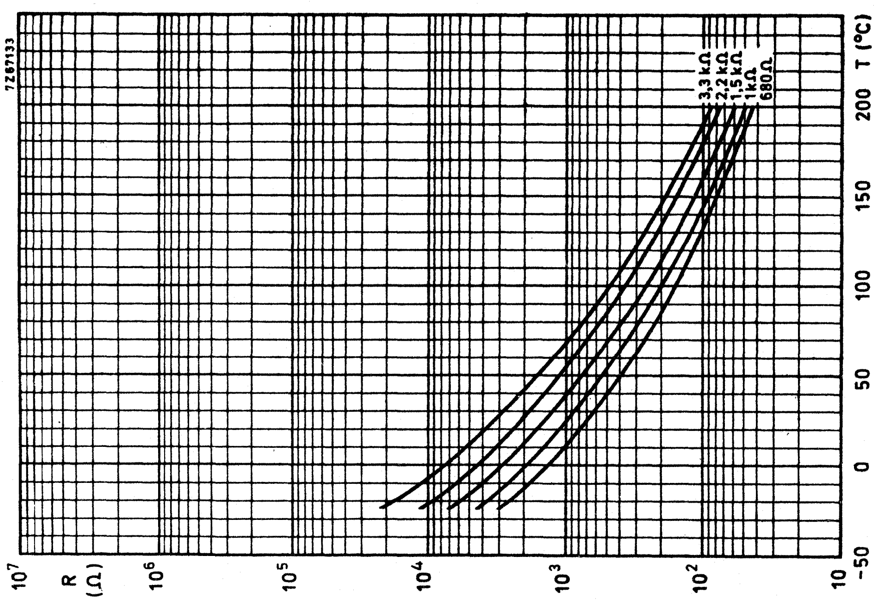
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 2,5 N	Ua	10 s	1)	−
Bending 1,25 N	Ub	2 times	1)	−
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ±1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must solderable initially anf after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

PACKAGING

100 pieces per box (cardboard)

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/°C
Thermal time constant	18 s
Operating temperature range	
at zero power	−55 to +300 °C
at maximum power	0 to +55 °C

APPLICATION

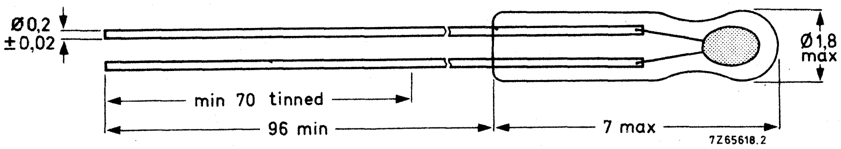
Intended for high temperature control.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

None

Mass

0,09 g approx.

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

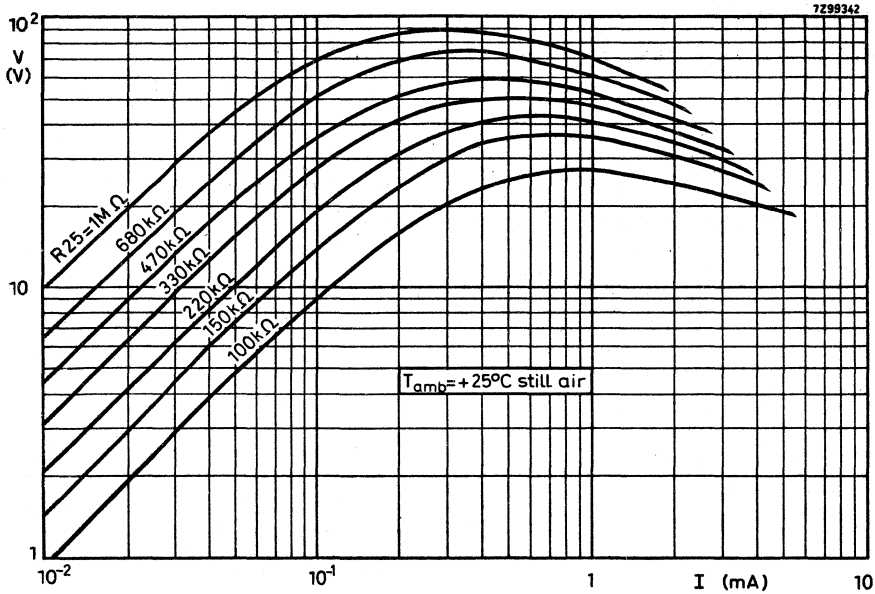
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

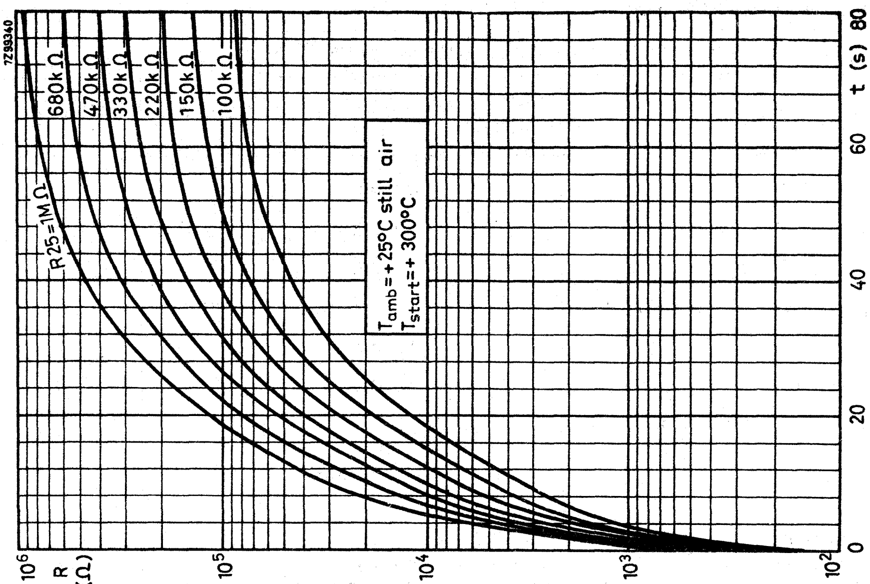
R_{25} ±20% Ω	$B_{25/85}$-value ± 5% K	catalogue number
100 000	3800	2322 627 31104
150 000	3880	31154
220 000	3920	31224
330 000	3980	31334
470 000	4030	31474
680 000	4100	31684
1000 000	4200	31105

Maximum dissipation at +55 °C	0,1 W
Dissipation factor *	0,95 mW/°C approx.
Thermal time constant *	18 s approx.
Heat capacity *	0,017 J/°C 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

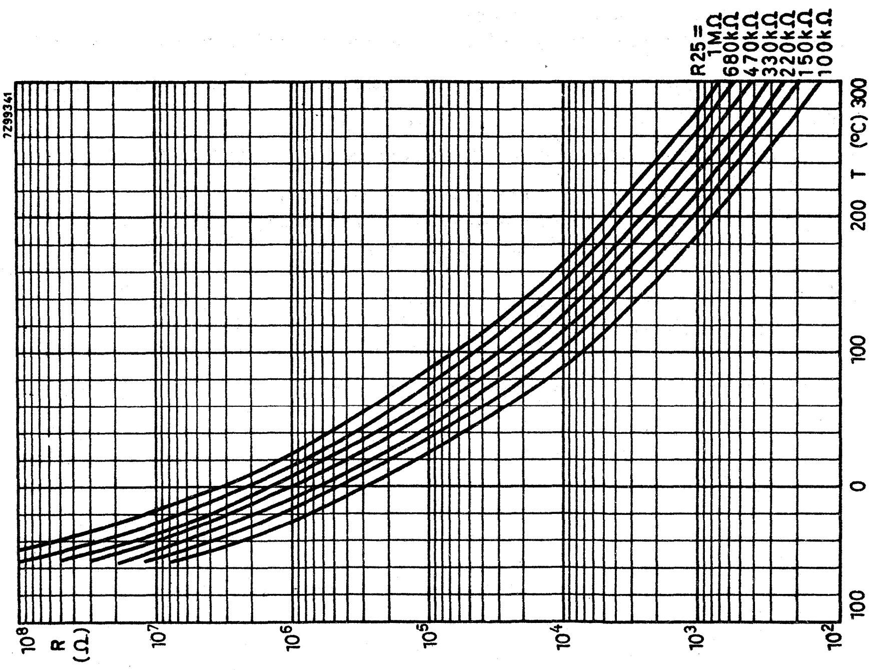
* Measurement made with specimen in phosphor-bronze clips, in still air.



Typical voltage/current characteristics



Typical resistance/time (cooling) characteristics



Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −55 °C	A	1000 h	± 2	± 2
Storage at +25 °C	H	1000 h	± 2	± 2
Dry heat +300 °C	B	1000 h	± 3	± 2
Thermal shock −55 to +300 °C	Na	5 cycles	± 2	± 2
Damp heat	C	336 h	± 2	± 2
Max. dissipation at T_{amb} = +55 °C		1000 h	± 3	± 2
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	–
Bending 1, 25 N	Ub	2 times	1)	–
Soldering	T			
Solderability at 230 °C	par.3.2.3	3 to 4 s	2)	–
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

100 pieces per box (cardboard)

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

Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Outlines

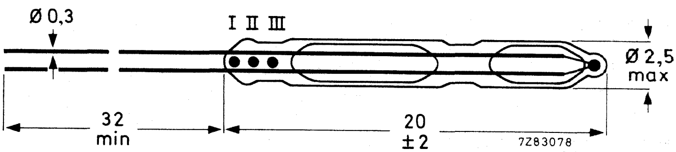


Fig. 1.

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

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.

R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/K	colour code * I	II	III	catalogue number 2322 627 4.... tol. 10%	tol. 20%
680	2200	–2,5	blue	grey	brown	2681	1681
1 000	2375	–2,7	brown	black	red	2102	1102
1 500	2500	–2,8	brown	green	red	2152	1152
2 200	2600	–2,9	red	red	red	2222	1222
3 300	2750	–3,1	orange	orange	red	2332	1332
4 700	3725	–4,2	yellow	violet	red	2472	1472
6 800	3775	–4,3	blue	grey	red	2682	1682
10 000	3875	–4,4	brown	black	orange	2103	1103
15 000	3800	–4,3	brown	green	orange	2153	1153
22 000	3850	–4,3	red	red	orange	2223	1223
33 000	3800	–4,3	orange	orange	orange	2333	1333
47 000	3850	–4,3	yellow	violet	orange	2473	1473
68 000	3900	–4,4	blue	grey	orange	2683	1683
100 000	3800	–4,3	brown	black	yellow	2104	1104
150 000	3880	–4,4	brown	green	yellow	2154	1154
220 000	3920	–4,4	red	red	yellow	2224	1224
330 000	3980	–4,5	orange	orange	yellow	2334	1334
470 000	4030	–4,5	yellow	violet	yellow	2474	1474
680 000	4100	–4,6	blue	grey	yellow	2684	1684

* For a tolerance on R_{25} of 10% a silver colour dot is added.

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

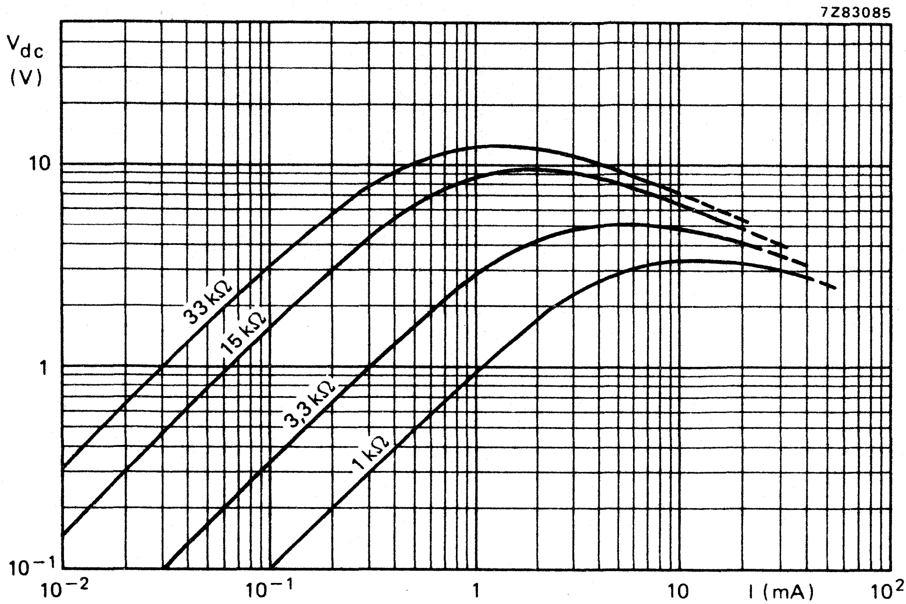


Fig. 2 Typical voltage/current characteristics.
T_{amb} = + 25 °C, still air.

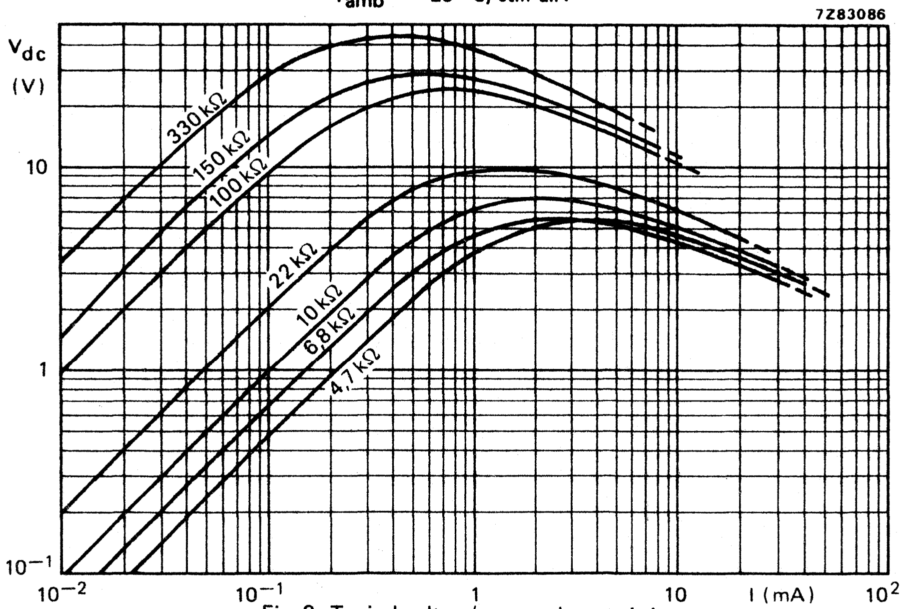


Fig. 3 Typical voltage/current characteristics.
T_{amb} = + 25 °C, still air.

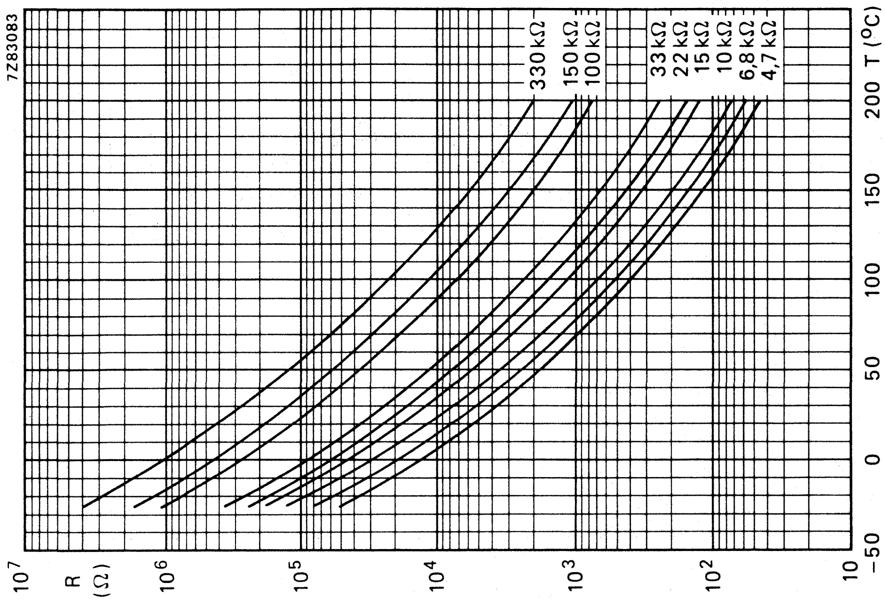


Fig. 5.

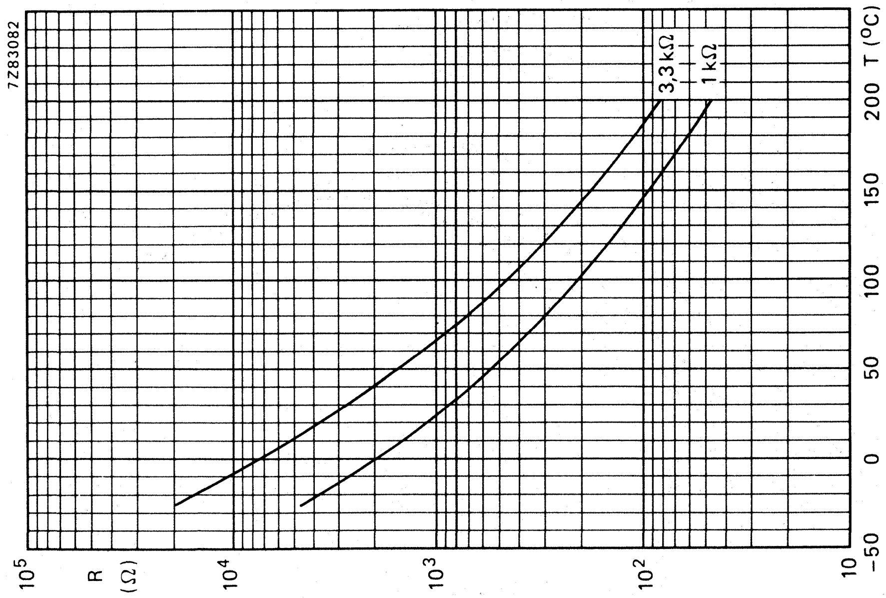


Fig. 4.

Typical resistance/temperature characteristics.

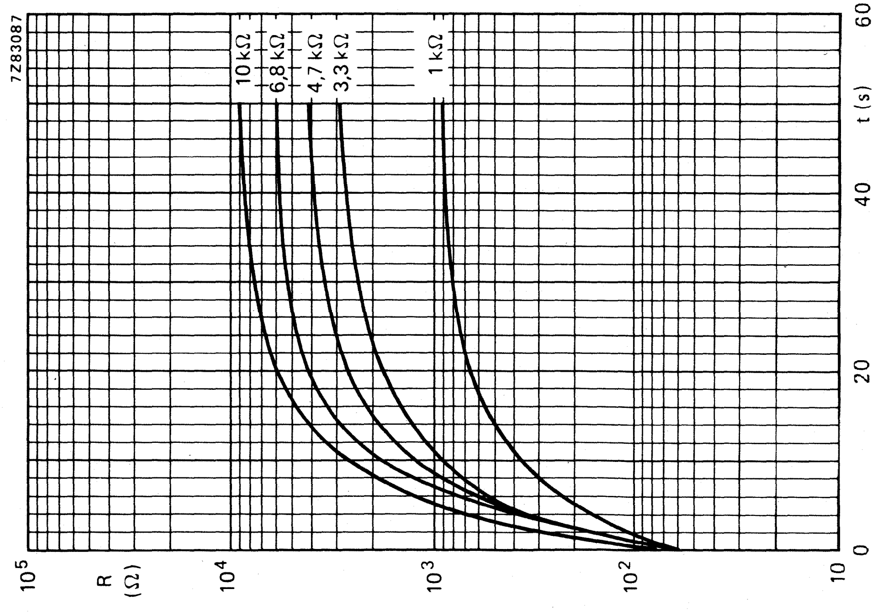


Fig. 6.

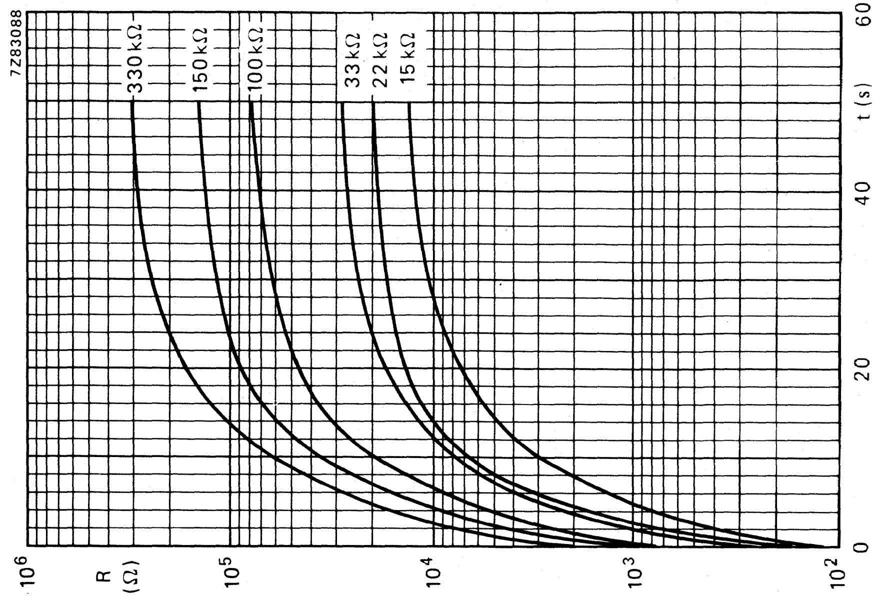


Fig. 7.

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

TESTS AND REQUIREMENTS

According to IEC 539 unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	56 days	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Climatic sequence	(note 1)		± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 2,5 N	Ua	10 s	(note 2)	
Bending 1,25 N	Ub	2 times	(note 2)	
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	(note 3)	
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	(note 4)	

Notes

1. CECC par. 4.16 secr. 333 January 1975.
2. Leads should neither come loose nor break.
3. Leads must be solderable initially and after 6 months storage with solder containing resin flux.
4. No visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical.

PACKAGING

100 pieces per box (cardboard).

NTC THERMISTORS

miniature bead

QUICK REFERENCE DATA

Resistance value at + 25 °C	680 Ω to 1 MΩ (E6 series)
$B_{25/85}$-value	2200 to 4200 K
Maximum dissipation	25 mW
Dissipation factor	1 mW/K
Thermal time constant	24 s
Operating temperature range	
at zero power	–25 to + 200 °C
at maximum power	0 to + 55 °C

APPLICATION

Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Outlines

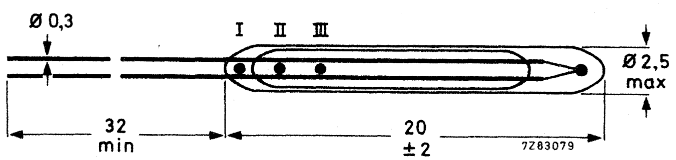


Fig. 1.

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

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.

R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/K	colour code* I	II	III	catalogue number 2322 627 5. . . . tol. 10%	tol. 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1 000	2375	−2,7	brown	black	red	2102	1102
1 500	2500	−2,8	brown	green	red	2152	1152
2 200	2600	−2,9	red	red	red	2222	1222
3 300	2750	−3,1	orange	orange	red	2332	1332
4 700	3725	−4,2	yellow	violet	red	2472	1472
6 800	3775	−4,3	blue	grey	red	2682	1682
10 000	3875	−4,4	brown	black	orange	2103	1103
15 000	3800	−4,3	brown	green	orange	2153	1153
22 000	3850	−4,3	red	red	orange	2223	1223
33 000	3800	−4,3	orange	orange	orange	2333	1333
47 000	3850	−4,3	yellow	violet	orange	2473	1473
68 000	3900	−4,4	blue	grey	orange	2683	1683
100 000	3800	−4,3	brown	black	yellow	2104	1104
150 000	3880	−4,4	brown	green	yellow	2154	1154
220 000	3920	−4,4	red	red	yellow	2224	1224
330 000	3980	−4,5	orange	orange	yellow	2334	1334
470 000	4030	−4,5	yellow	violet	yellow	2474	1474
680 000	4100	−4,6	blue	grey	yellow	2684	1684
1 000 000	4200	−4,7	brown	black	green	2105	1105

* For a tolerance on R_{25} of 10% a silver colour dot is added.

Maximum dissipation (P)	25 mW (see Fig. 2)
Dissipation factor	1 mW/K approx.
Thermal time constant	24 s approx.
Operating temperature range at zero power at maximum power	 −25 to + 200 °C 0 to + 55 °C
Dielectric withstanding voltage (r.m.s.) between terminals and glass envelope	 min. 100 V
Insulation resistance between terminals and galss envelope at 10 V (d.c.)	 min. 10 MΩ

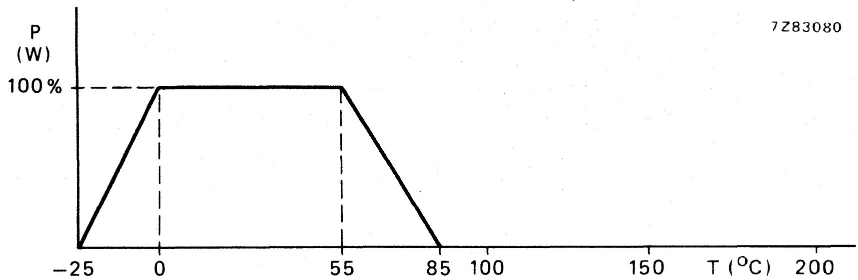


Fig. 2.

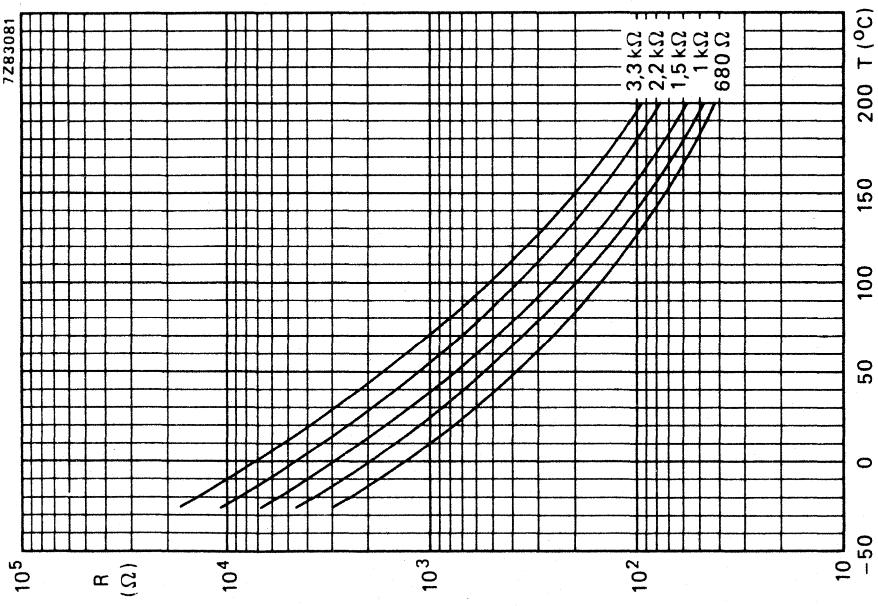


Fig. 3.

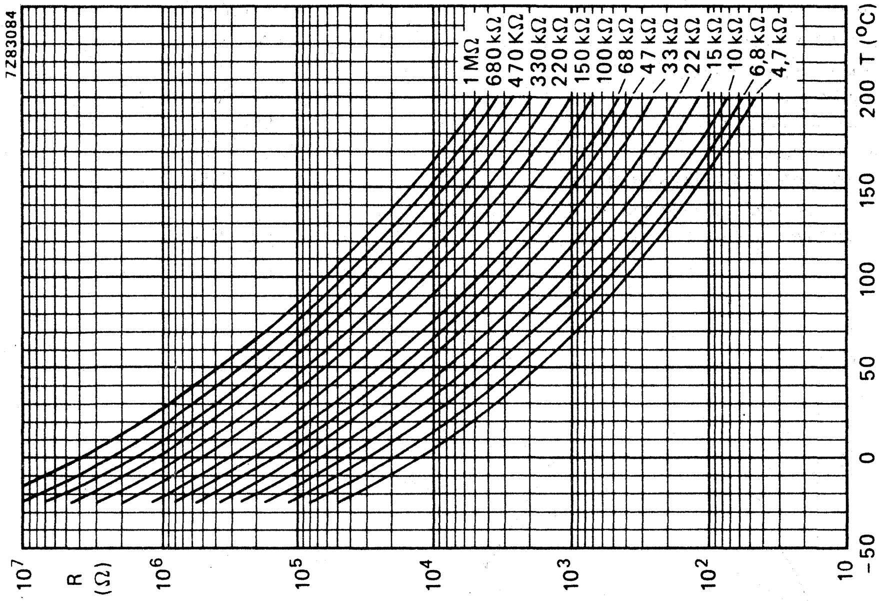


Fig. 4.

Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 539 unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at + 25 °C	H	1000 h	± 2	± 1
Dry heat at + 200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to + 200 °C	Na	5 cycles	± 2	± 1
Damp heat at + 40 °C	C	56 days	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Climatic sequence	(note 1)		± 3	± 1
Max. dissipation at T_{amb} = + 25 °C		1000 h	± 3	± 1
Rbustness of terminations	U			
Tensile strength 2,5 N	Ua	10 s	(note 2)	
Bending 1,25 N	Ub	2 times	(note 2)	
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	(note 3)	
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	(note 4)	

Notes
1. CECC par. 4.16 secr. 333 January 1975.
2. Leads should neither come loose nor break.
3. Leads must be solderable initially and after 6 months storage with solder containing resin flux.
4. Neither electrical nor visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD 105D.

A.Q.L. 0,25%, – Inoperatives
A.Q.L. 1 %, – Electrical
A.Q.L. 1,5 %, – Mechanical

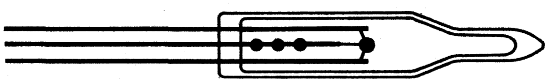
PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

indirectly heated

QUICK REFERENCE DATA	
Resistance value at +25 °C	3,3 kΩ and 330 kΩ
Resistance of heater	100 Ω ± 10%
$B_{25/85}$-value	2750 °K and 4275 °K
Maximum dissipation of thermistor at W_h = 0 mW	35 mW
Dissipation factor	0,18 mW/deg C
Thermal time constant	15 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

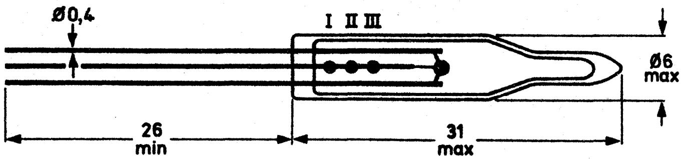
For temperature control

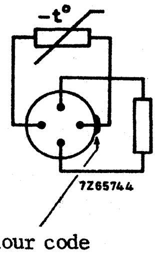
DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)





Marking

Three colour dots on the glass envelope:

type	I	II	III
2322 628 01332	orange	orange	red
2322 628 01334	orange	orange	yellow

Weight

0,95 g approx.

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

Inflammability

Uninflammable

ELECTRICAL DATA

Unless otherwise specified measured according to IEC draft publication 40 (CO) 408.

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

	2322 628 01332	2322 628 01334
Resistance at 25 °C	3,3 kΩ ± 20%	330 kΩ ± 20%
Resistance of heater	100Ω ± 10%	100Ω ± 10%
Resistance after $t \leq 30$ s and $W_h = 30$ mW	< 10% of R_{25}	< 2,5% of R_{25}
$B_{25/85}$-value	2750 K ± 5%	4275 K ± 5%
Temperature coefficient	−3,1%/°C	−4,8%/°C

Maximum dissipation of thermistor at zero power of heater ($W_h = 0$)	35 mW
Maximum dissipation of heater at zero power in thermistor ($W_{th} = 0$)	35 mW
Dissipation factor	0,18 mW/°C
Thermal time constant	15 s
Heat capacity	0,0027 J/°C
Heater efficiency	97,5%
Capacitance between heater and thermistor	1,6 pF
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 of thermistor and heater	min 200 V
Insulation resistance at 50 V between terminals of thermistor and heater	min 10 MΩ

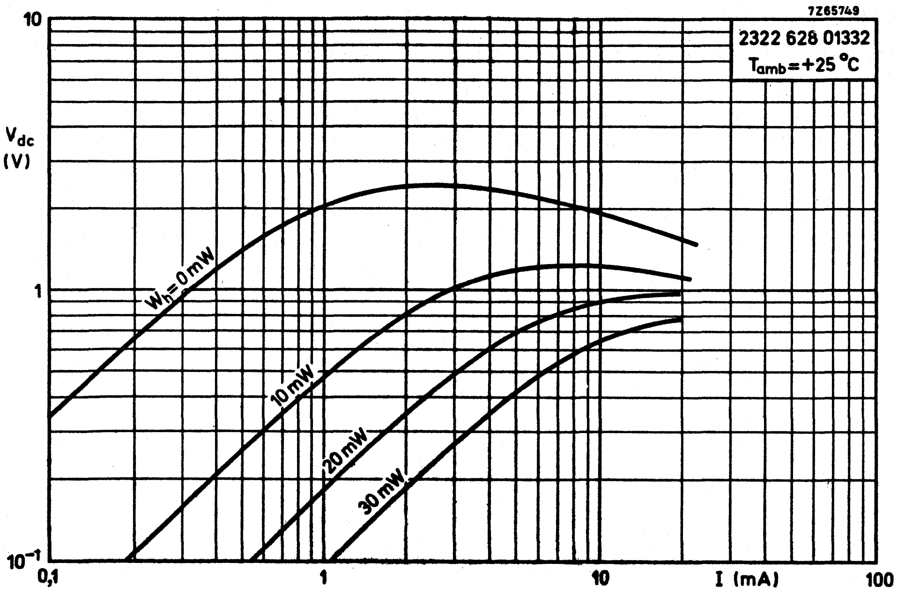


Fig.2 Typical voltage/current characteristics

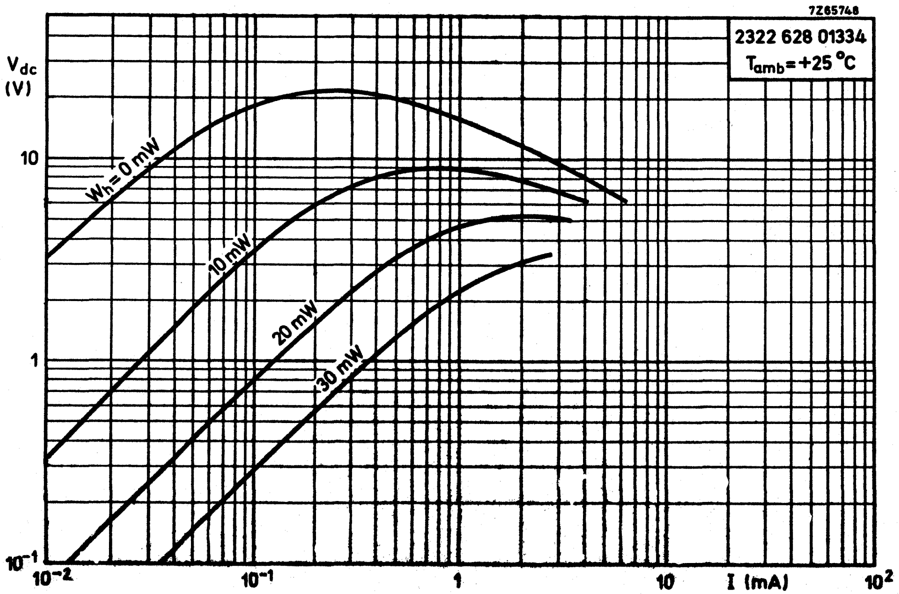


Fig.3 Typical voltage/current characteristics

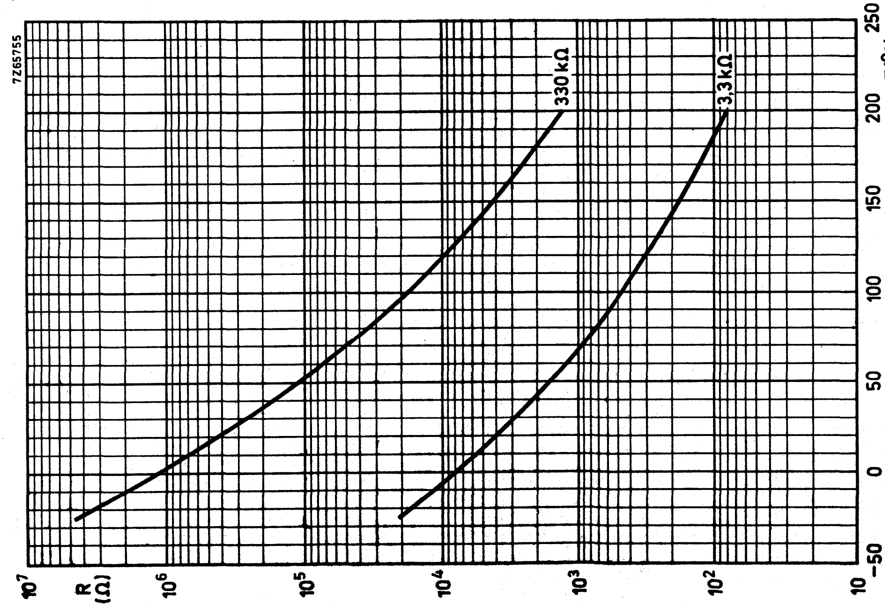


Fig.4 Typical resistance/temperature characteristics

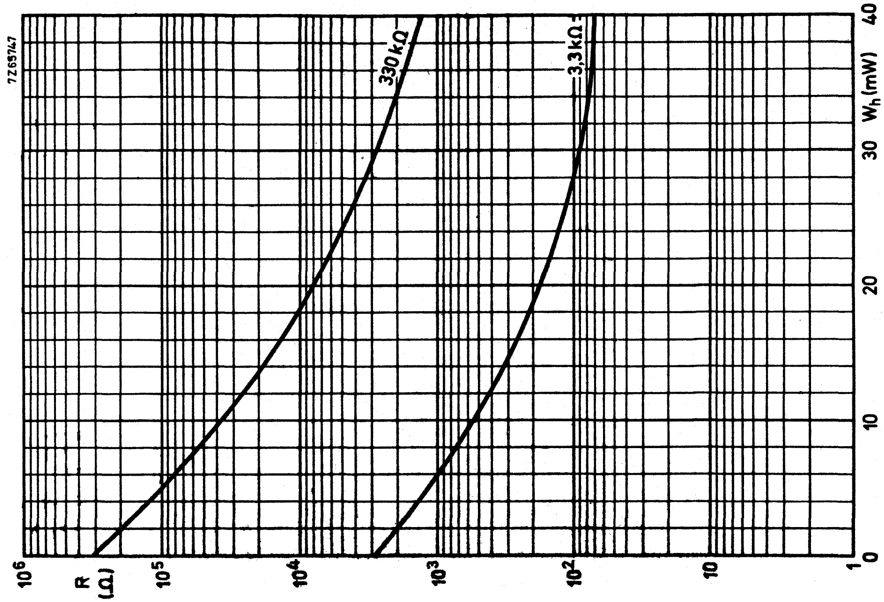


Fig.5 Typical resistance/heater power characteristics

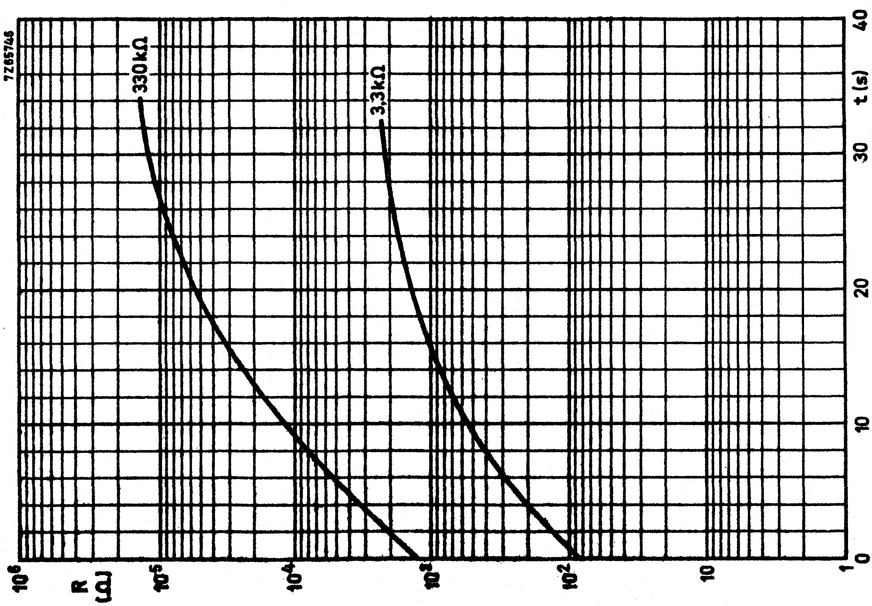


Fig.6 Typical resistance/time (cooling) characteristics

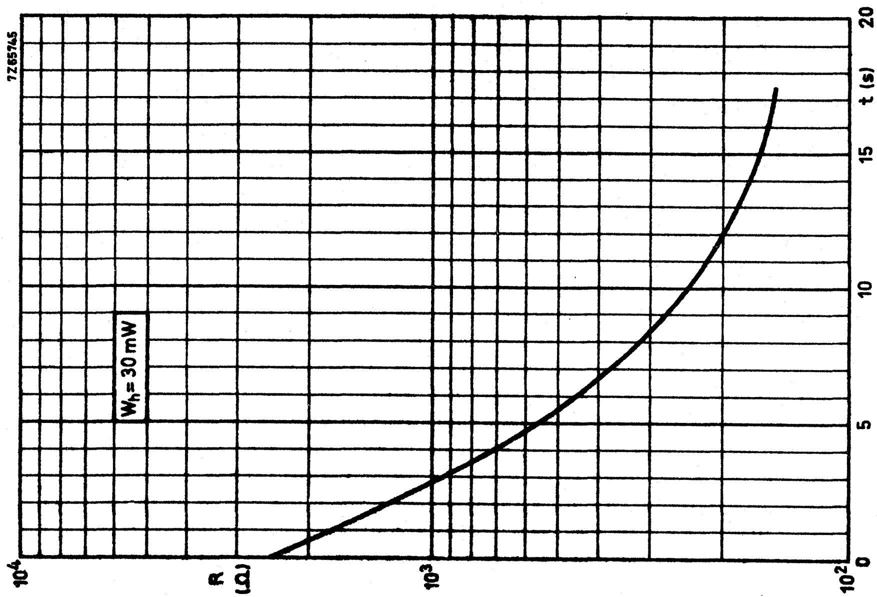


Fig.7 Typical resistance/response time characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations unless otherwise specified

test	test method	duration	$\frac{\Delta R25}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	±2	±1
Storage at +25 °C	H	1000 h	±1	±1
Dry heat at +200 °C	B	1000 h	±3	±1
Thermal shock −25 to +200 °C	Na	5 cycles	±2	±1
Damp heat at +40 °C	C	1000 h	±2	±1
Dissipation in damp heat		336 h	±3	±1
Max. dissipation at T_{amb} = +25 °C		1000 h	±3	±1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	−
Bending 2,5 N	Ub	2 times	1)	−
Soldering	T		1)	−
Solderability	par. 3.2.3.	3 to 4 s	2)	−
Resistance to heat	Tb	10 ± 1 s	±2	±2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects-Electrical
A.Q.L. 1,5%, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

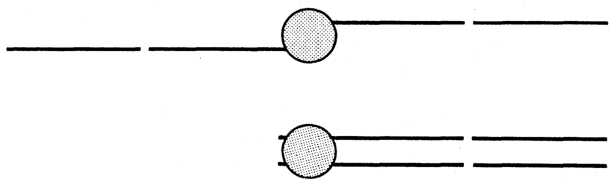
PACKAGING

100 pieces per box (cardboard)

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

Intended for general use.

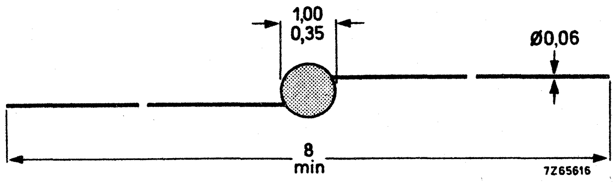
DESCRIPTION

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

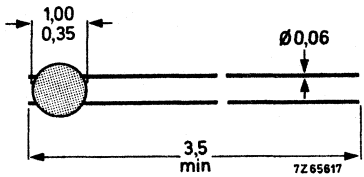
MECHANICAL DATA

Dimensions (mm)

version 2322 634 0. . . .



version 2322 634 1. . . .



Marking

None

Weight

0,001 g approx.

Mounting

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

Inflammability

Uninflammable

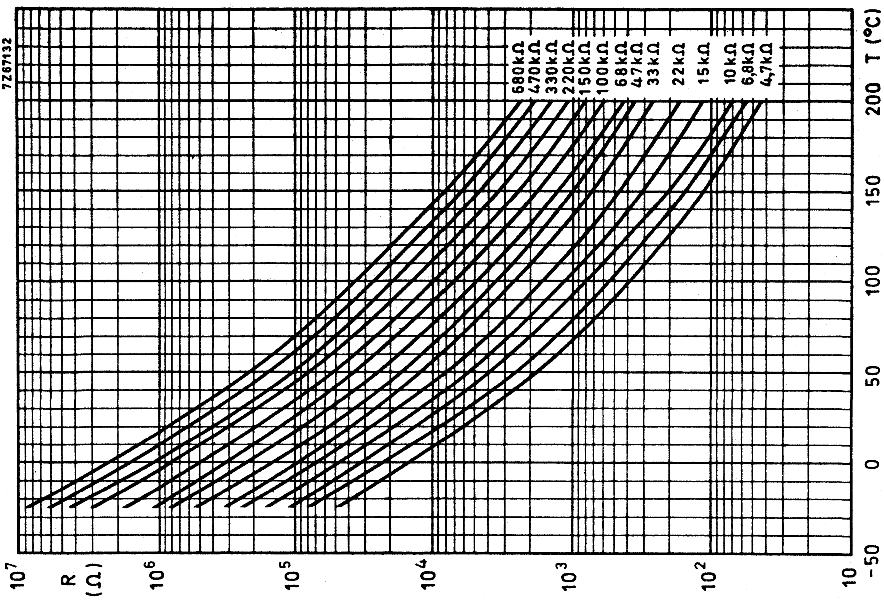
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

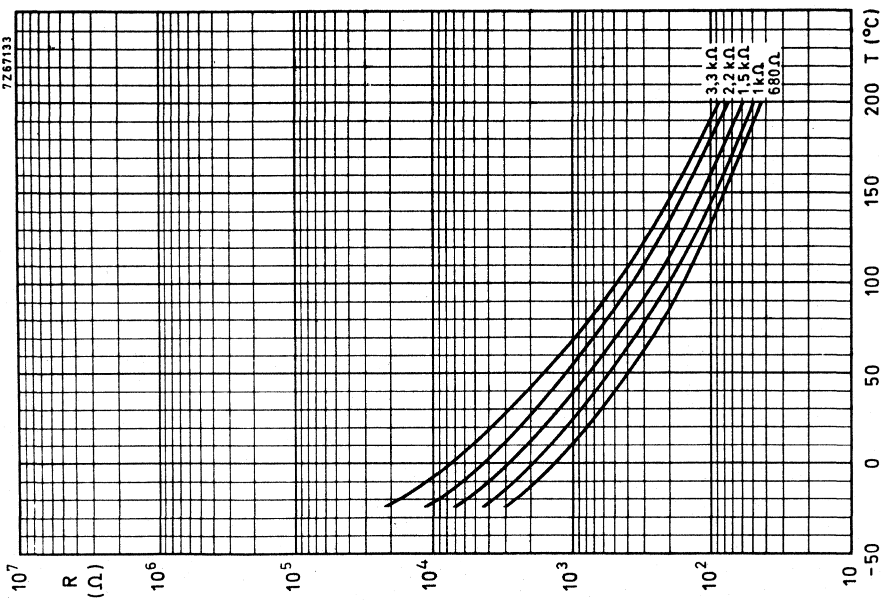
R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/°C	catalogue number 2322 634 0.... leads in opposition tol. 10%	catalogue number 2322 634 0.... leads in opposition tol. 20%	catalogue number 2322 634 1.... leads in same direction tol. 10%	catalogue number 2322 634 1.... leads in same direction tol. 20%
680	2200	−2,5	2681	1681	2681	1681
1000	2375	−2,7	2102	1102	2102	1102
1500	2500	−2,8	2152	1152	2152	1152
2200	2600	−2,9	2222	1222	2222	1222
3300	2750	−3,1	2332	1332	2332	1332
4700	3725	−4,2	2472	1472	2472	1472
6800	3775	−4,3	2682	1682	2682	1682
10000	3875	−4,3	2103	1103	2103	1103
15000	3800	−4,3	2153	1153	2153	1153
22000	3850	−4,3	2223	1223	2223	1223
33000	3800	−4,3	2333	1333	2333	1333
47000	3850	−4,3	2473	1473	2473	1473
68000	3900	−4,4	2683	1683	2683	1683
100000	3800	−4,3	2104	1104	2104	1104
150000	3880	−4,4	2154	1154	2154	1154
220000	3920	−4,4	2224	1224	2224	1224
330000	3980	−4,5	2334	1334	2334	1334
470000	4030	−4,5	2474	1474	2474	1474
680000	4100	−4,6	2684	1684	2684	1684

Heat capacity — 0,5 . 10^{-3} J/°C approx.

Operating temperature range
- at zero power — −25 to +200 °C
- at maximum power — 0 to +55 °C



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%. major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

100 pieces ber box (cardboard).

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/°C
Thermal time constant	9 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C

APPLICATION

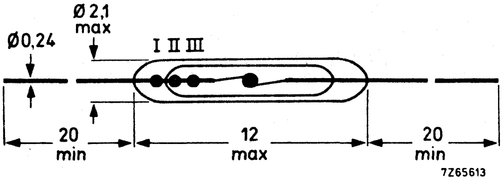
Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

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

Mass

0,1 g approx.

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

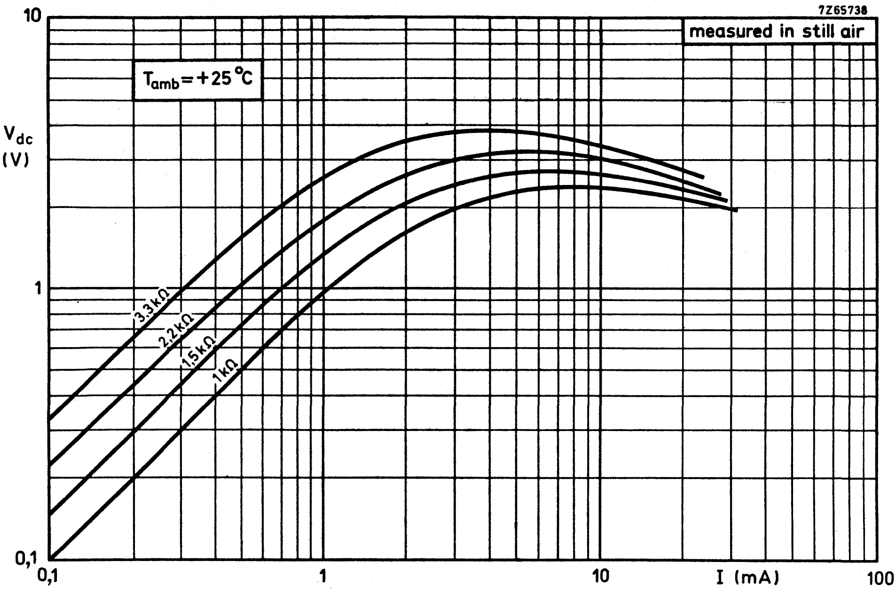
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

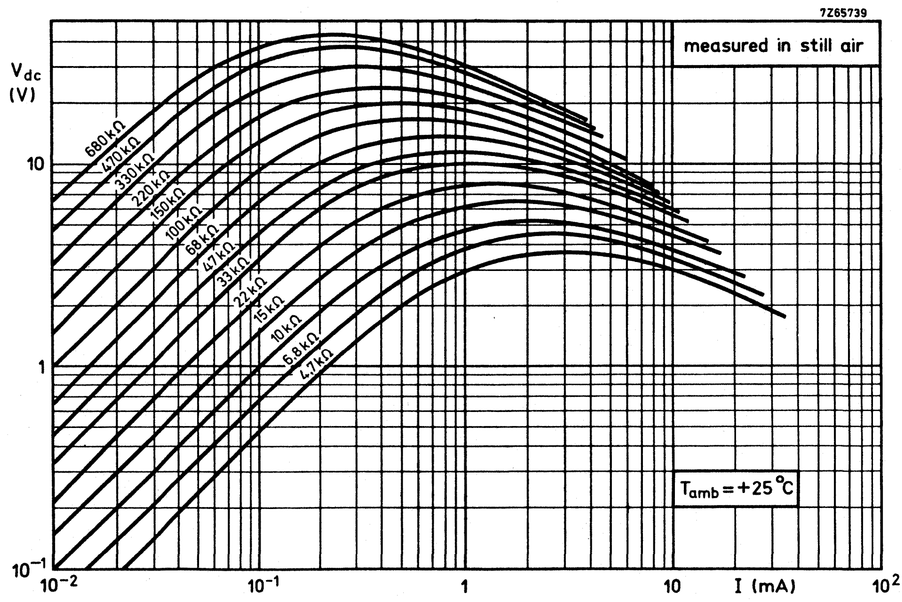
R25 Ω	B25/85-value ± 5% K	temperature coefficient at 25 °C %/°C	colour code * I	II	III	catalogue number 2322 634 2.... tol. ± 10% *	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3800	−4,3	brown	black	yellow	2104	1104
150000	3880	−4,4	brown	green	yellow	2154	1154
220000	3920	−4,4	red	red	yellow	2224	1224
330000	3980	−4,5	orange	orange	yellow	2334	1334
470000	4030	−4,5	yellow	violet	yellow	2474	1474
680000	4100	−4,6	blue	grey	yellow	2684	1684

* Only for 10% tolerance a silver dot is added to the colour code.

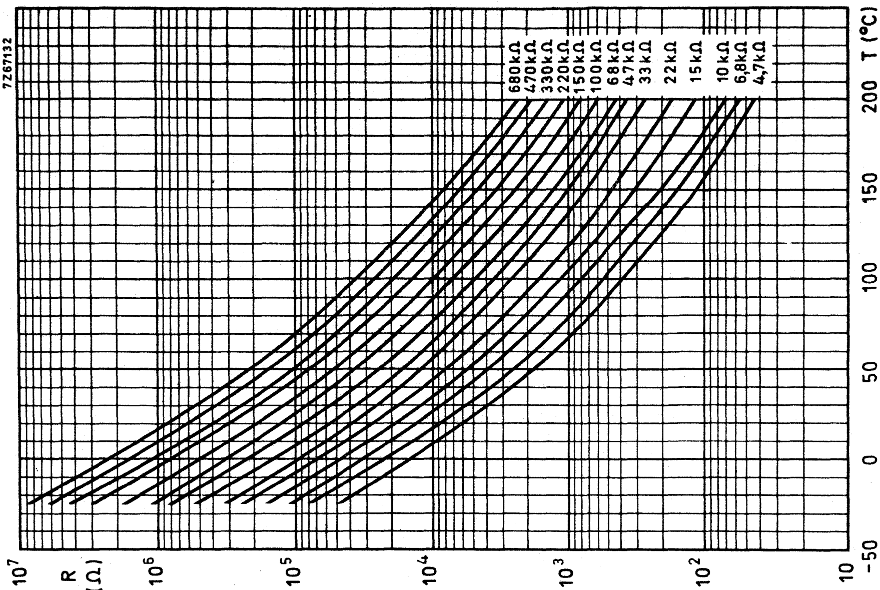
Maximum dissipation at +55 °C	60 mW
Dissipation factor	0,4 mW/°C approx.
Thermal time constant	9 s approx.
Heat capacity of ceramic	0,5 . 10^{-3} J/°C approx.
of complete component	3,1 . 10^{-3} J/°C approx.
Operating temperature range	
at zero power	-25 to +200 °C
at maximum power	0 to +55 °C
Dielectric 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



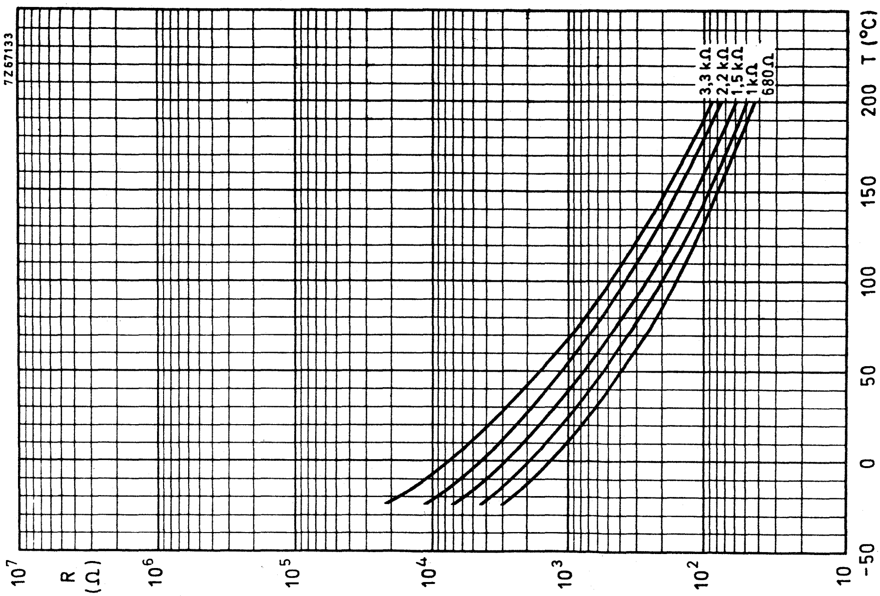
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h		
Robustness of terminations	U			
Tensile strength 2, 5 N	Ua	10 s	1)	−
Bending 1, 25 N	Ub	2 times	1)	−
Torsion	Uc	3 times	1)	−
Torque			1)	−
Soldering	T			
Solderability at max. 240 °C	par. 3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

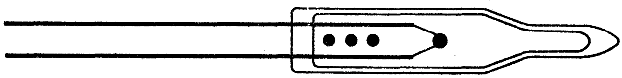
PACKAGING

100 pieces per box (cardboard).

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	20 mW
Dissipation factor	0,11 mW/°C
Thermal time constant	6 s
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to +55 °C



APPLICATION

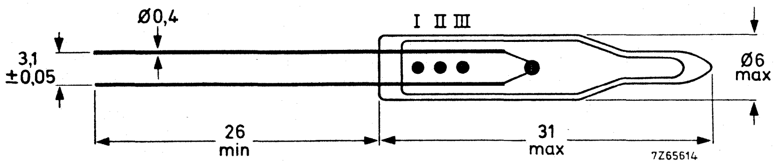
Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

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

Mass

0,6 g approx.

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

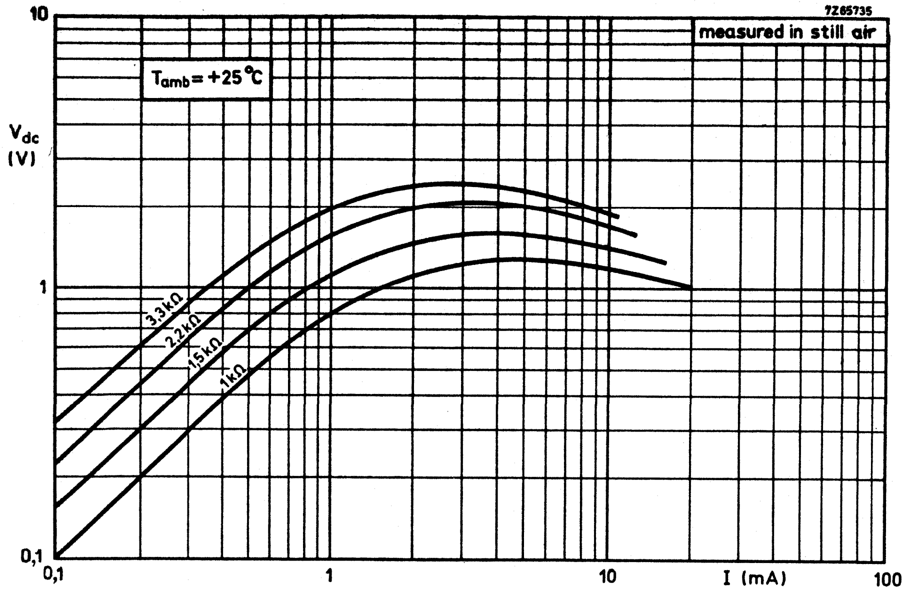
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

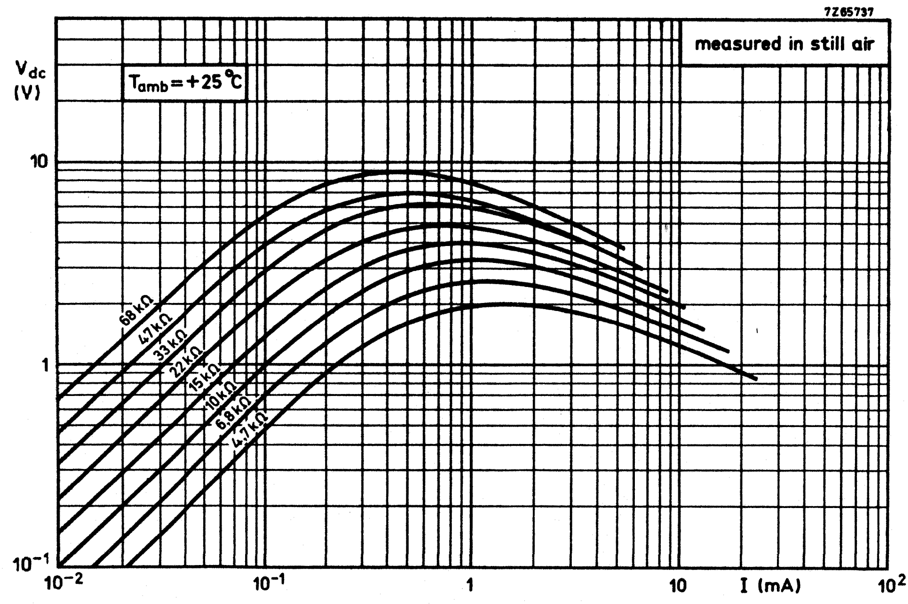
R_{25} Ω	$B_{25/85}$-value ± 5% K	temperature coefficient at 25 °C %/°C	colour code * I	II	III	catalogue number 2322 634 3.... tol. ± 10% *	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3800	−4,3	brown	black	yellow	2104	1104
150000	3880	−4,4	brown	green	yellow	2154	1154
220000	3920	−4,4	red	red	yellow	2224	1224
330000	3980	−4,5	orange	orange	yellow	2334	1334
470000	4030	−4,5	yellow	violet	yellow	2474	1474
680000	4100	−4,6	blue	grey	yellow	2684	1684

* Only for 10% tolerance a silver dot is added to the colour code.

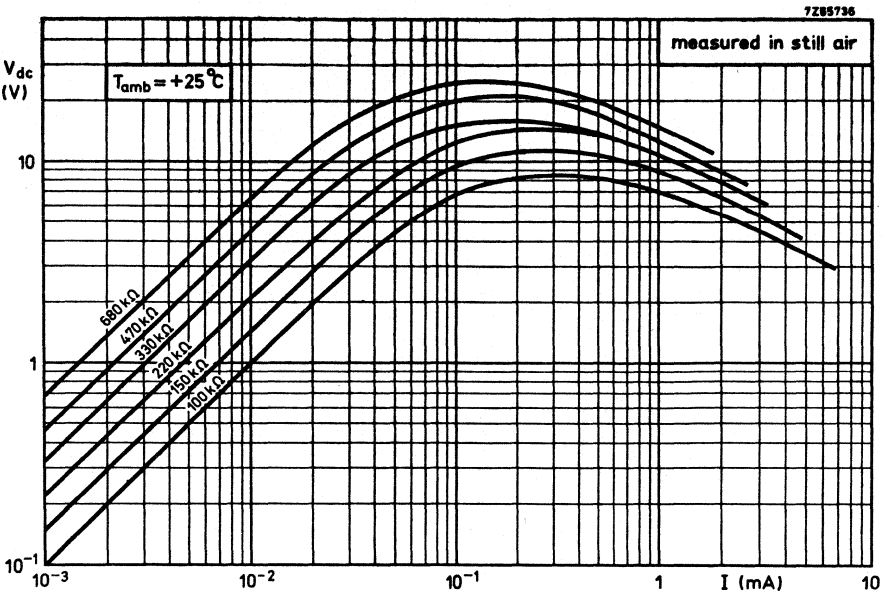
Maximum dissipation at +55 °C	20 mW
Dissipation factor	0,11 mW/°C approx.
Thermal time constant	6 s approx.
Heat capacity of ceramic	$0,5 \cdot 10^{-3}$ J/°C approx.
of complete component	$0,8 \cdot 10^{-3}$ J/°C approx.
Operating temperature range	
at zero power	−25 to +200 °C
at maximum power	0 to + 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



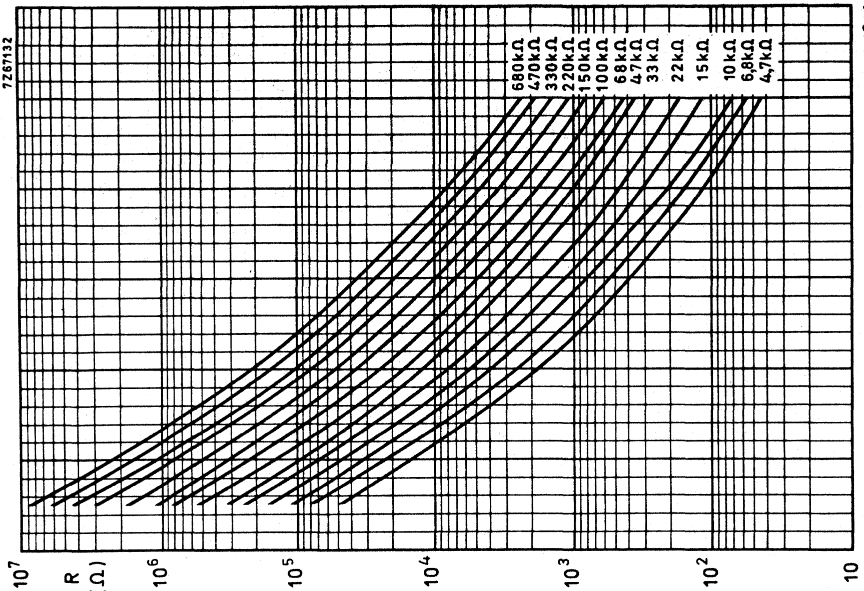
Typical voltage/current characteristics.



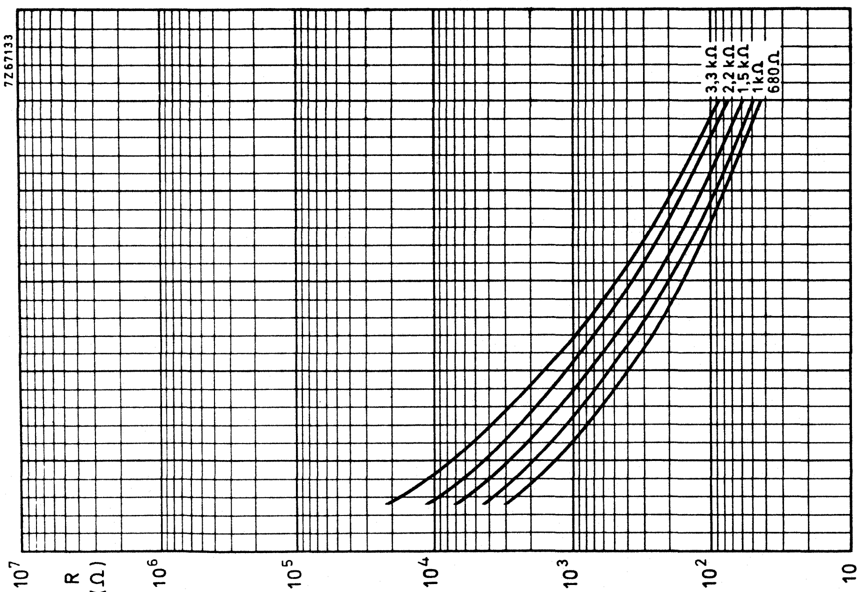
Typical voltage/current characteristics.



Typical voltage/current characteristics.



Typical resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	−
Bending 2, 5 N	Ub	2 times	1)	−
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	−
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5%, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

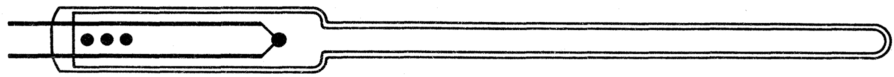
PACKAGING

100 pieces per box (cardboard).

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

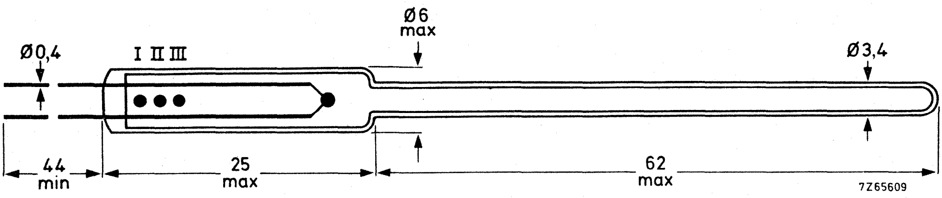
Intended for use as vacuum gauge.

DESCRIPTION

Bead thermistor with negative temperature coefficient mounted in a glass envelope with a stem and with two solid tinned copper wires.

MECHANICAL DATA

Dimensions (mm)



Marking

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

Mass

0,2 g approx.

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

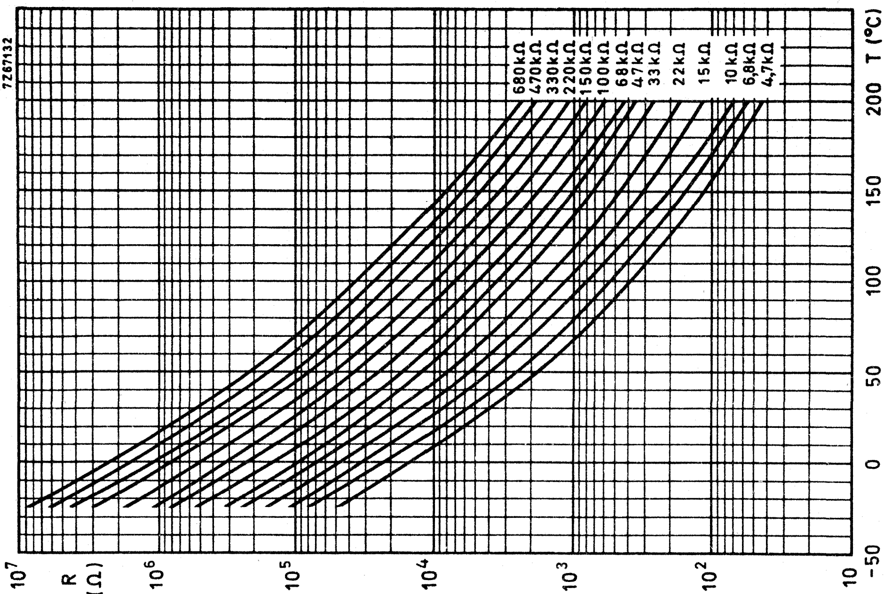
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

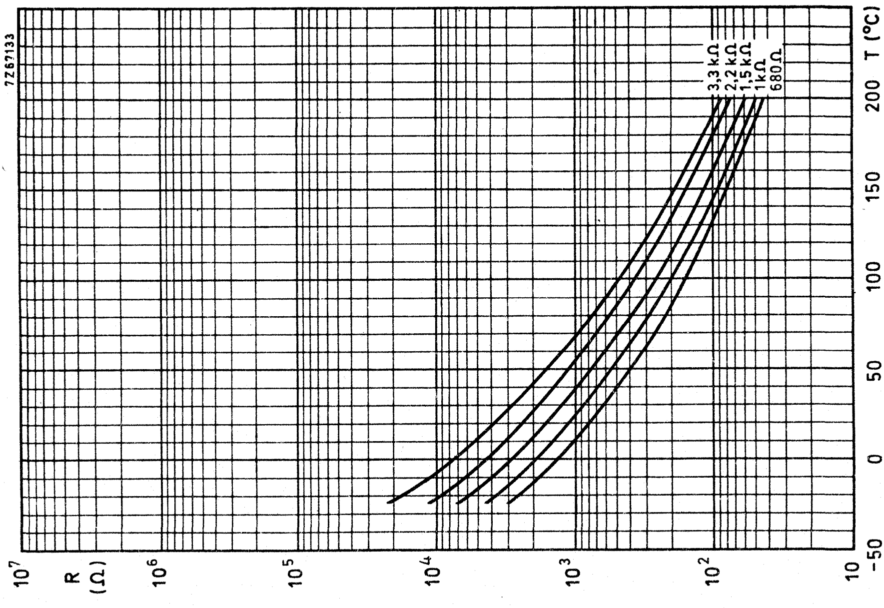
R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code *			catalogue number 2322 634 4....	
Ω	K	%/°C	I	II	III	tol. ± 10 *	tol. ± 20%
680	2200	−2,5	blue	grey	brown	2681	1681
1000	2375	−2,7	brown	black	red	2102	1102
1500	2500	−2,8	brown	green	red	2152	1152
2200	2600	−2,9	red	red	red	2222	1222
3300	2750	−3,1	orange	orange	red	2332	1332
4700	3725	−4,2	yellow	violet	red	2472	1472
6800	3775	−4,3	blue	grey	red	2682	1682
10000	3875	−4,3	brown	black	orange	2103	1103
15000	3800	−4,3	brown	green	orange	2153	1153
22000	3850	−4,3	red	red	orange	2223	1223
33000	3800	−4,3	orange	orange	orange	2333	1333
47000	3850	−4,3	yellow	violet	orange	2473	1473
68000	3900	−4,4	blue	grey	orange	2683	1683
100000	3800	−4,3	brown	black	yellow	2104	1104
150000	3880	−4,4	brown	green	yellow	2154	1154
220000	3920	−4,4	red	red	yellow	2224	1224
330000	3980	−4,5	orange	orange	yellow	2334	1334
470000	4030	−4,5	yellow	violet	yellow	2474	1474
680000	4100	−4,6	blue	grey	yellow	2684	1684

* Only for 10% tolerance a silver dot is added to the colour code.

Heat capacity of ceramic	0,5 . 10^{-3} J/°C 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 resistance/temperature characteristics.



Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	± 2	± 1
Storage at +25 °C	H	1000 h	± 2	± 1
Dry heat at +200 °C	B	1000 h	± 3	± 1
Thermal shock −25 to +200 °C	Na	5 cycles	± 2	± 1
Damp heat at +40 °C	C	1000 h	± 2	± 1
Dissipation in damp heat		336 h	± 3	± 1
Max. dissipation at T_{amb} = +25 °C		1000 h	± 3	± 1
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	–
Bending	Ub	2 times	1)	–
Soldering	T			
Solderability at max. 240 °C	par.3.2.3	3 to 4 s	2)	–
Resistance to heat at 260 ± 5 °C	Tb	10 ±1 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

200 pieces per box (cardboard).

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

Intended for general use

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

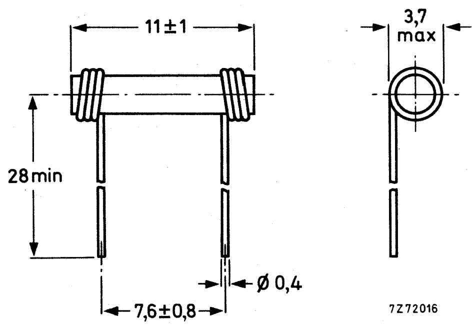


Fig.1

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 termination

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

Unless otherwise specified measured according to IEC publication 539.

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

Maximum dissipation 0, 6 W

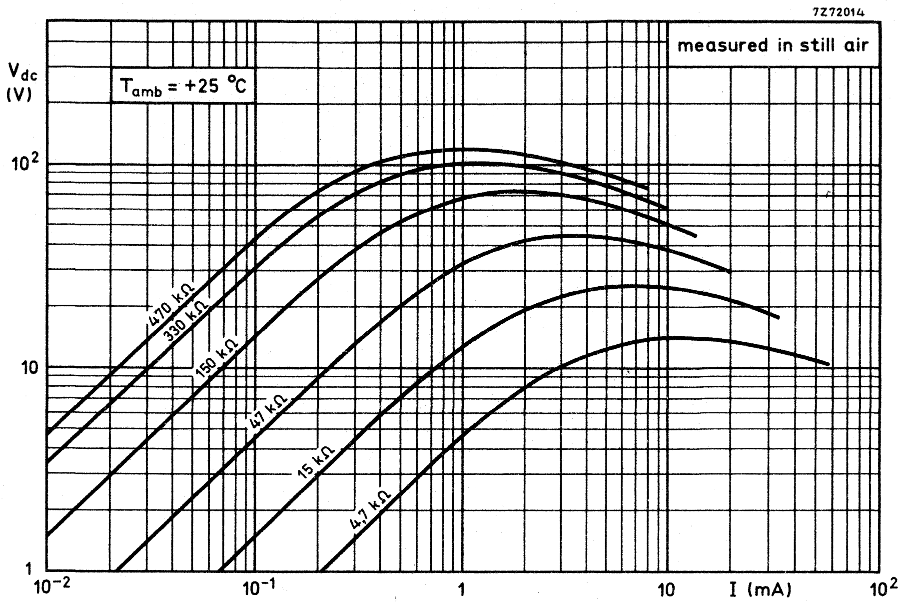
Dissipation factor 5 mW/ °C *

Thermal time constant 30 s *

Heat capacity of ceramic 0, 135 J/ °C *
of complete component 0, 150 J/ °C *

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.
**) On R_{25}.



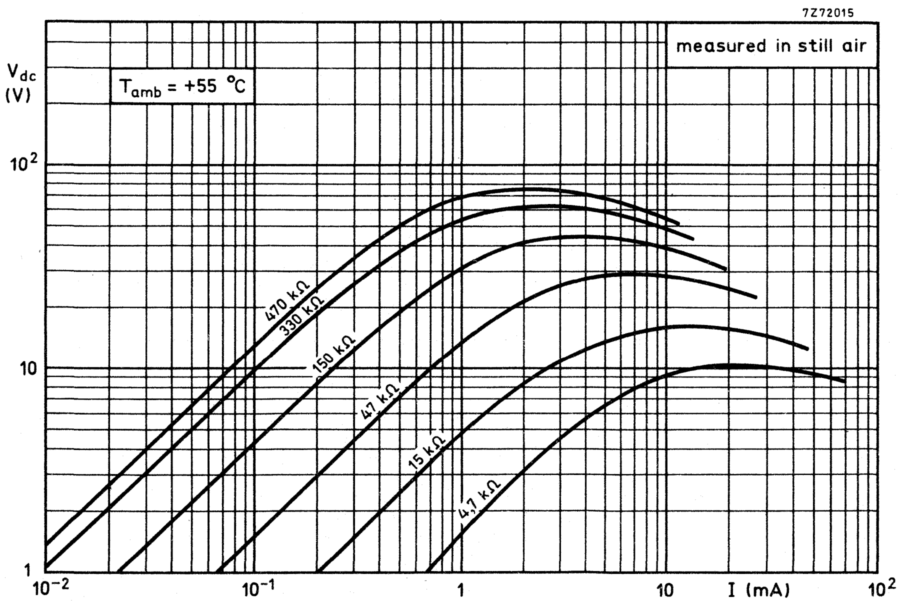


Fig. 2a and b. Typical voltage/current characteristics

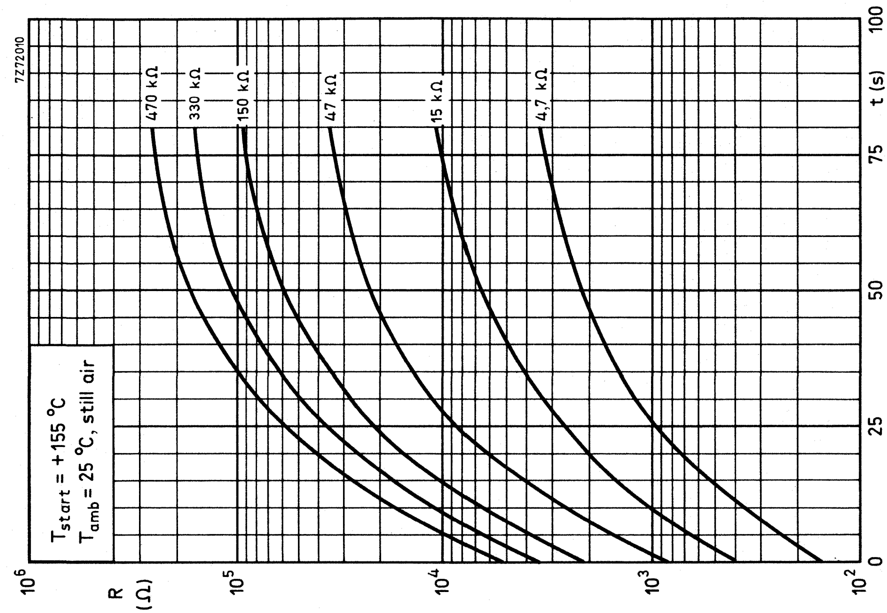


Fig. 4 Typical resistance/time (cooling) characteristics

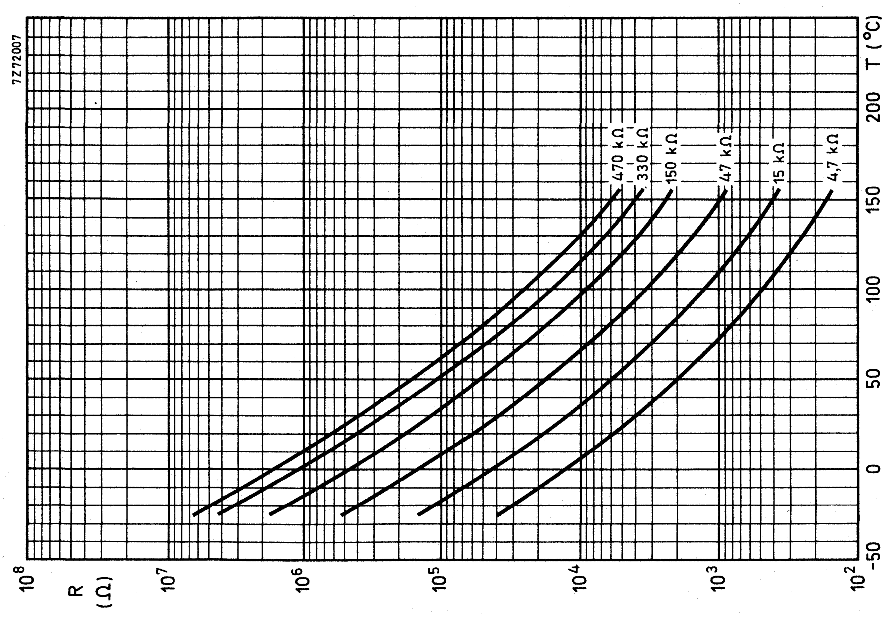


Fig. 3 Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	[1]	
Bending 2,5 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 260 °C	Tb	10 ± 1 s	± 2	± 2

[1] Leads should neither come loose nor break

[2] Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 250

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/°C
Thermal time constant	55 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

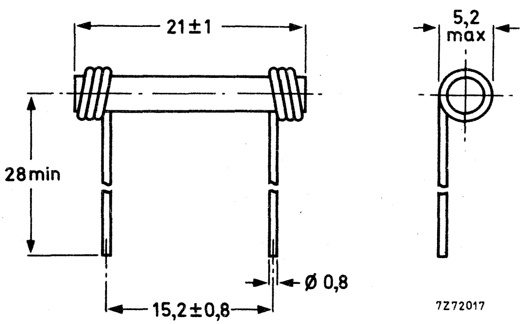


Fig. 1

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 termination

Tensile strength	20 N
Bending	10 N

Soldering

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

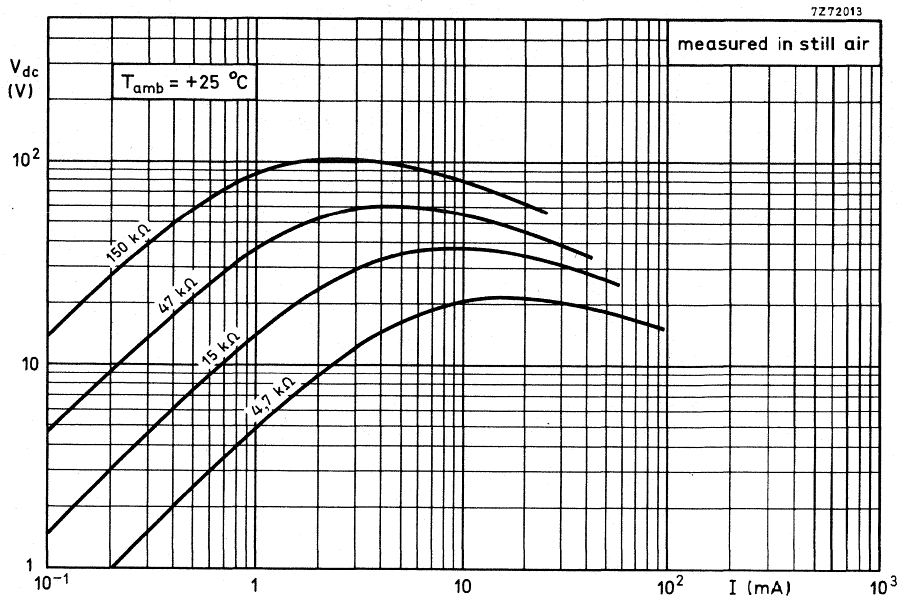
ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

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

Maximum dissipation	1,5 W	
Dissipation factor	10 mW/°C	*
Thermal time constant	55 s	*
Heat capacity of ceramic	0,44 J/°C	*
of complete component	0,55 J/°C	*
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.
** On R_{25}.



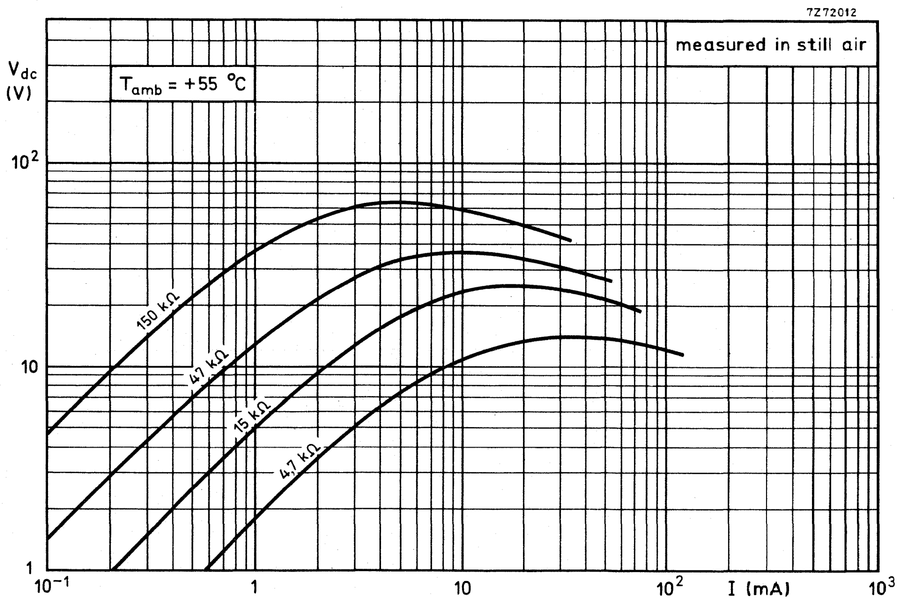


Fig. 2a and b. Typical voltage/current characteristics

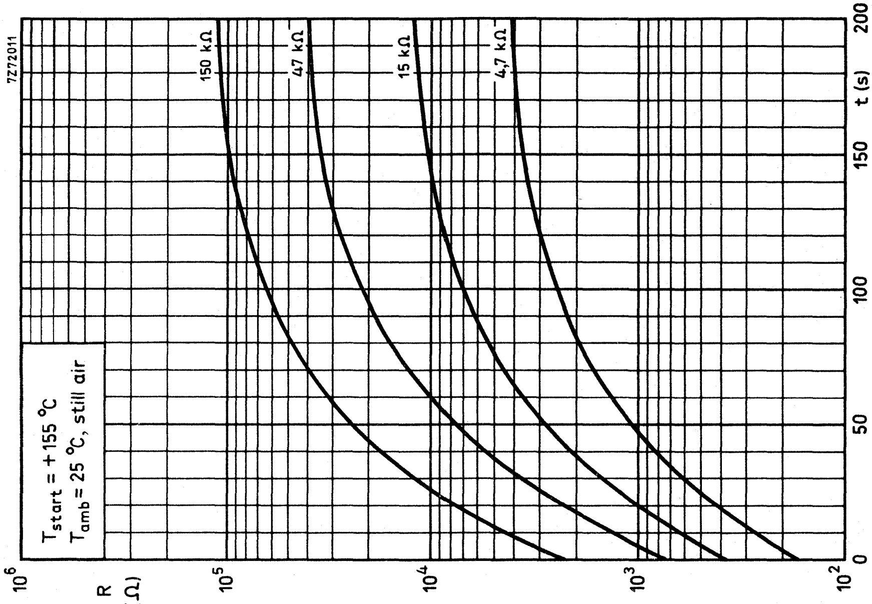


Fig. 4 Typical resistance/time (cooling) characteristics

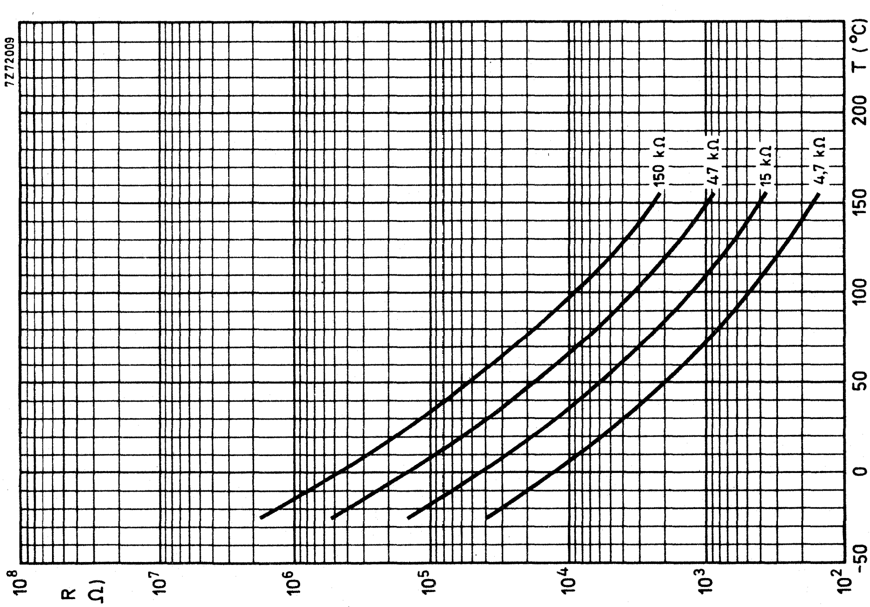


Fig. 3 Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 260 °C	Tb	10 ±1 s	± 2	± 2

[1]) Leads should neither come loose nor break

[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 100

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/ °C
Thermal time constant	105 s
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

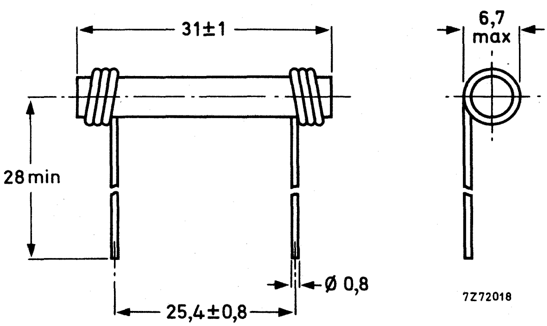


Fig. 1

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

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

R_{25} kΩ	$B_{25/85}$ ± 5% K	temperature coefficient * %/°C	colour code	catalogue number tol. ± 20%	catalogue number tol. ± 10% **
4,7	3200	− 3,6	orange	2322 637 01472	2322 637 02472
15	3550	− 4,0	green	2322 637 01153	2322 637 02153
47	3750	− 4,2	blue	2322 637 01473	2322 637 02473
150	4200	− 4,7	white	2322 637 01154	2322 637 02154

Maximum dissipation	2,3 W	
Dissipation factor	17 mW/°C	*
Thermal time constant	105 s	*
Heat capacity	1,785 J/°C	*
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.
** On R_{25}.

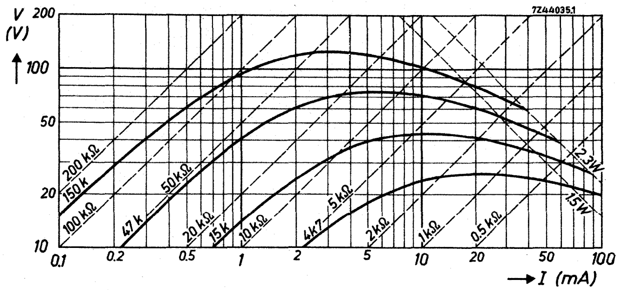


Fig. 2 Typical voltage/current characteristics

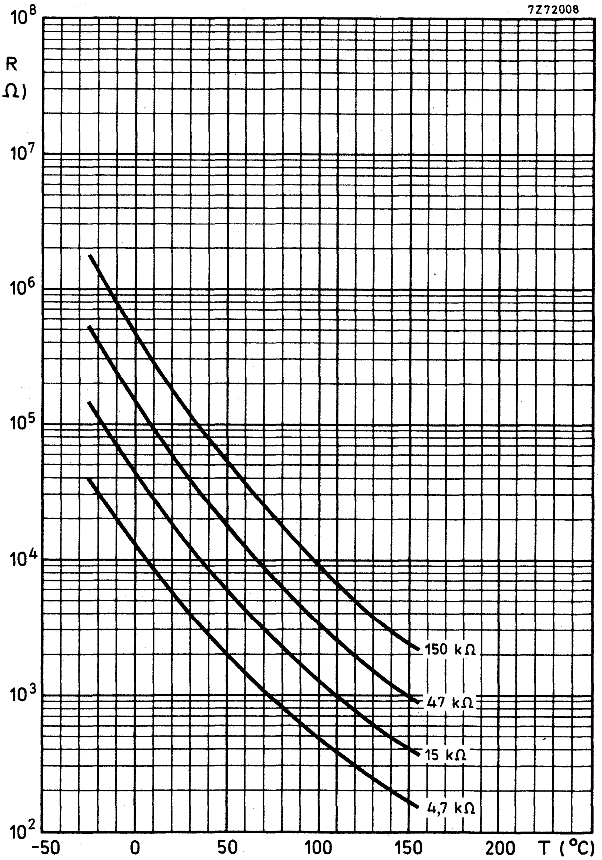


Fig. 3 Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔB/B (%)
Cold at −25 °C	A	1000 h	± 3	± 2
Storage at +25 °C	H	1000 h	± 3	± 1
Dry heat, +155 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +155 °C	Na	5 cycles	± 3	± 2
Damp heat, +40 °C	Ca	1000 h	± 5	± 3
Maximum dissipation		1000 h	± 5	± 2
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 260 °C	Tb	10 ± 1 s	± 2	± 2

1) Leads should neither come loose nor break

2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKING

In cardboard boxes of 50

NTC THERMISTOR

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

Intended for general use.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Outlines

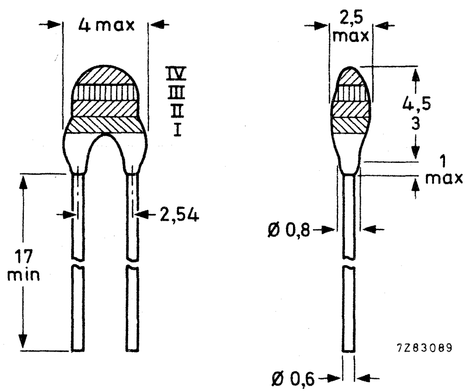


Fig. 1.

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

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

R_{25} Ω	$B_{25/85}$ ±5% K	$B_{-25/25}$ K	temperature coefficient at +25 °C %/K	colour code * I	II	III	catalogue number 2322 640 1.... R_{25} ± 10%	R_{25} ± 20%
2 700	4000	3800	−4,50	red	violet	red	2272	1272
4 700	3660	3440	−4,12	yellow	violet	red	2472	1472
12 000	3700	3540	−4,17	brown	red	orange	2123	1123
22 000	3700	3420	−4,17	red	red	orange	2223	1223
47 000	3850	3570	−4,33	yellow	violet	orange	2473	1473
68 000	3880	3590	−4,37	blue	grey	orange	2683	1683
150 000	4050	3740	−4,56	brown	green	yellow	2154	1154
330 000	4150	3830	−4,67	orange	orange	yellow	2334	1334

* A silver band (IV) is added to the colour code only for 10% tolerance.

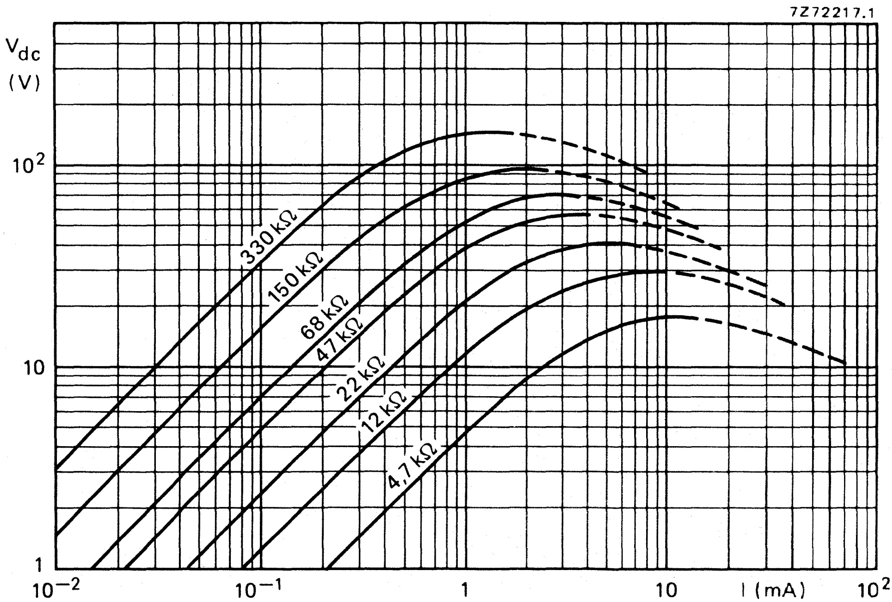


Fig. 2 Typical voltage/current characteristics. T_{amb} = +25 °C, still air.

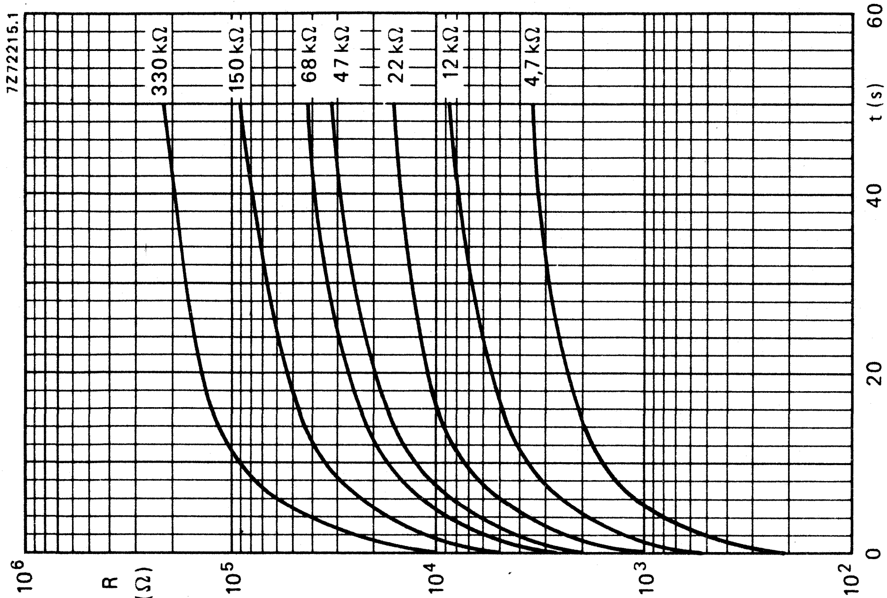


Fig. 4 Typical resistance/time (cooling) characteristic.
T_{amb} = + 25 °C, still air; T_{start} = + 125 °C.

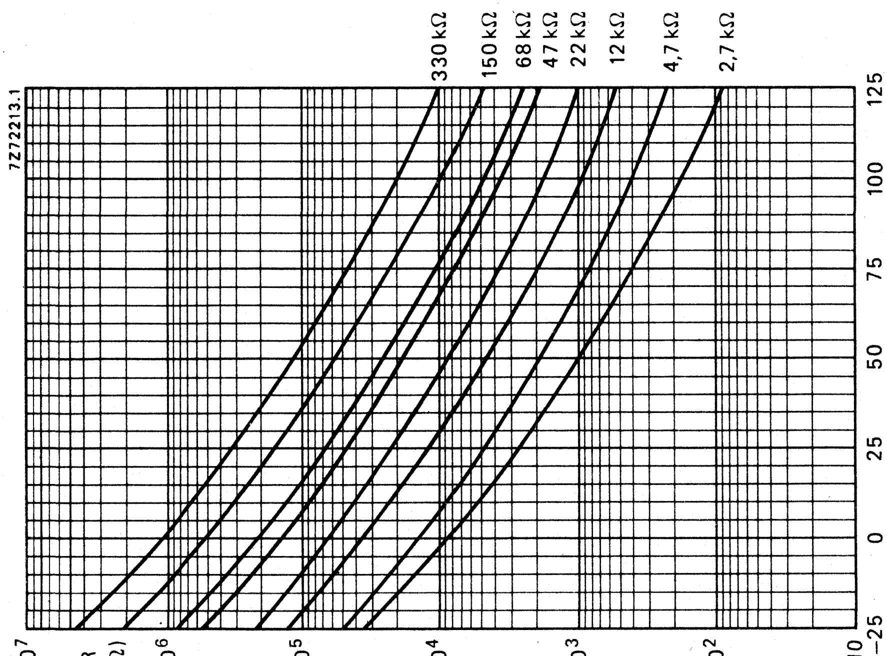


Fig. 3 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	procedure	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold	A	1000 h −25 °C	±3	±2
Storage	H	1000 h +25 °C	±3	±1
Dry heat	B	1000 h +125 °C	±5	±2
Thermal shock	Na	5 cycles −25 to +125 °C	±3	±2
Damp heat	Ca	1000 h +40 °C	±5	±3
Combined cycle test	19 B	NF C20-619	±5	±3
Maximum dissipation		1000 h, T_{amb} = +55 °C	±5	±2
Robustness of terminations	U			
Tensile strength	Ua	10 N 10 s	(note 1)	
Bending	Ub	5 N 2 times	(note 1)	
Soldering	T			
Solderability	par. 3.2.3	max. 240 °C, 3 to 4 s	(note 2)	
Resistance to heat	Tb	260 ± 5 °C, 10 ± 1 s	ΔR_{25} ± 2%	ΔB ± 2%
Impact				
Free fall	Ed	2 falls of 1 m	no visual defects	
Inflammability		needle flame 20 s	no burning 15 s after removal of flame	
Resistance to solvents		ICI cleaning process for p.c.b.:		
		Arklone P	no influence	
		Arklone L, boiling	slight softening after 10 min.	
		Freon TF	no influence	

Notes
1. Leads should neither come loose nor break.
2. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.
- A.Q.L. 1%, major defects — Electrical
- A.Q.L. 1,5%, major defects — Mechanical
- A.Q.L. 4%, minor defects — Physical

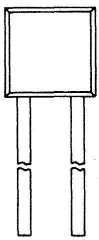
PACKAGING

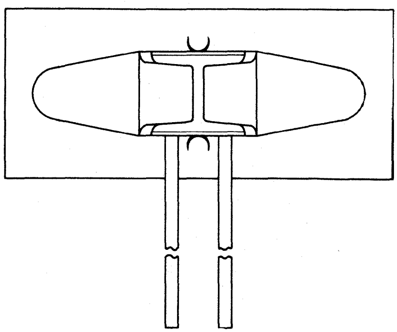
500 pieces per box (cardboard).

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/°C
when mounted on a heat-sink	19	27	mW/°C
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

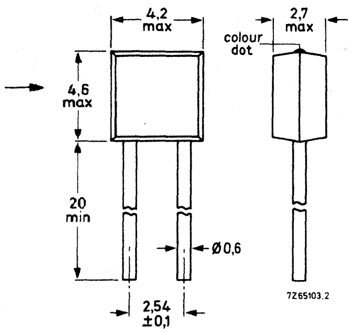
For temperature control.

DESCRIPTION

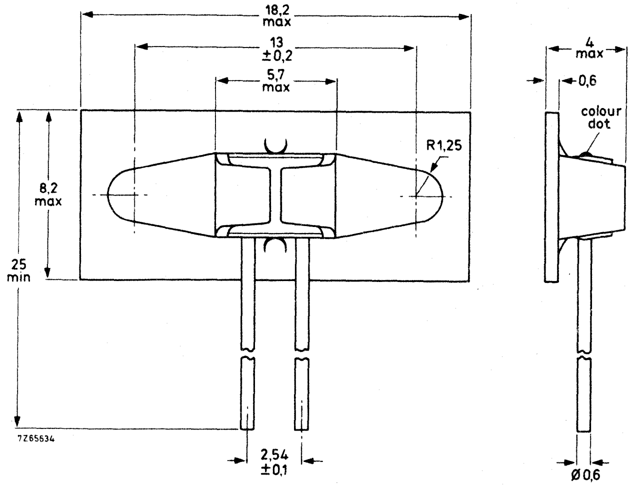
Moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires. The body colour is black.
The thermistor 2322 640 98004 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



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.

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	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/°C
when mounted on a heatsink *	19	27	mW/°C
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/°C
of complete component	0,13	0,3	J/°C
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 (ϕ 1,3 mm).

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

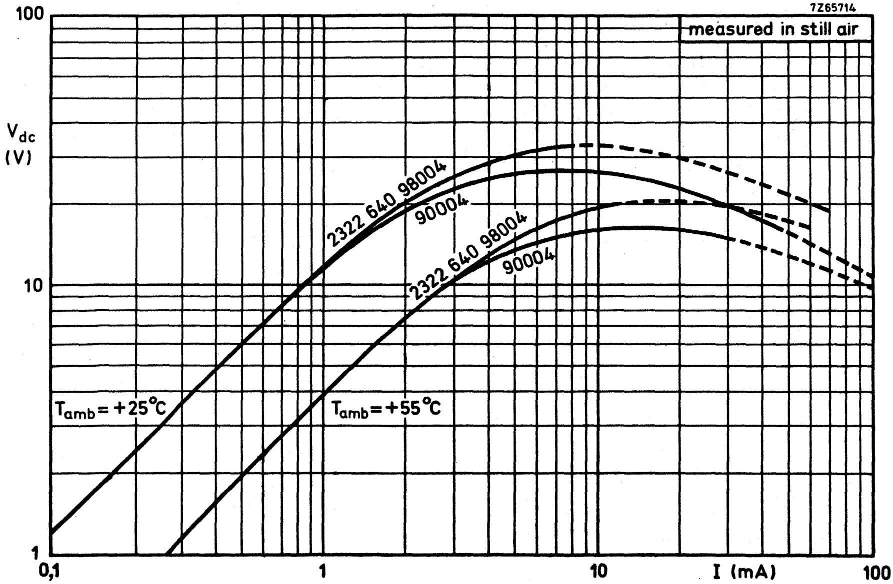


Fig. 2 Typical voltage/current characteristics.

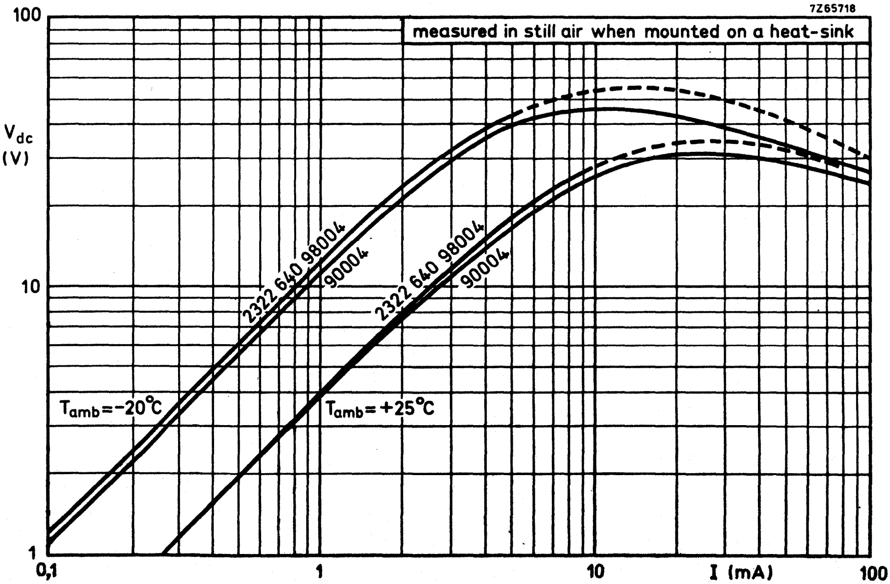


Fig. 3 Typical voltage/current characteristics.

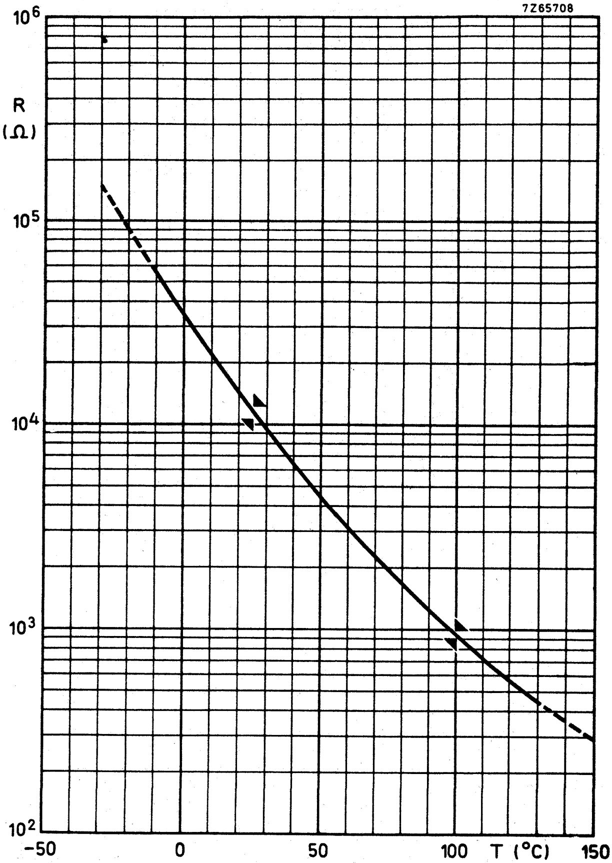


Fig.4 Typical resistance/temperature characteristics.

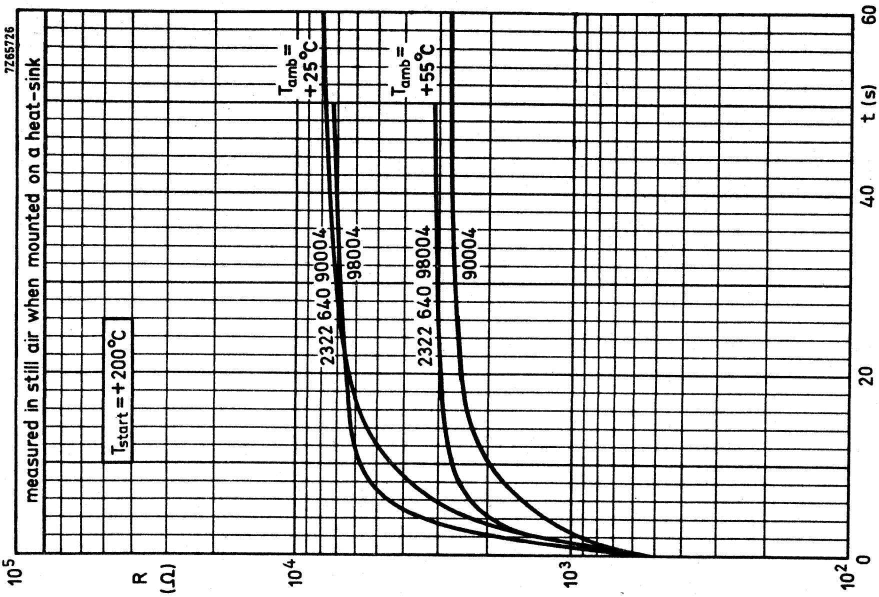


Fig. 6 Typical resistance/time (cooling) characteristics.

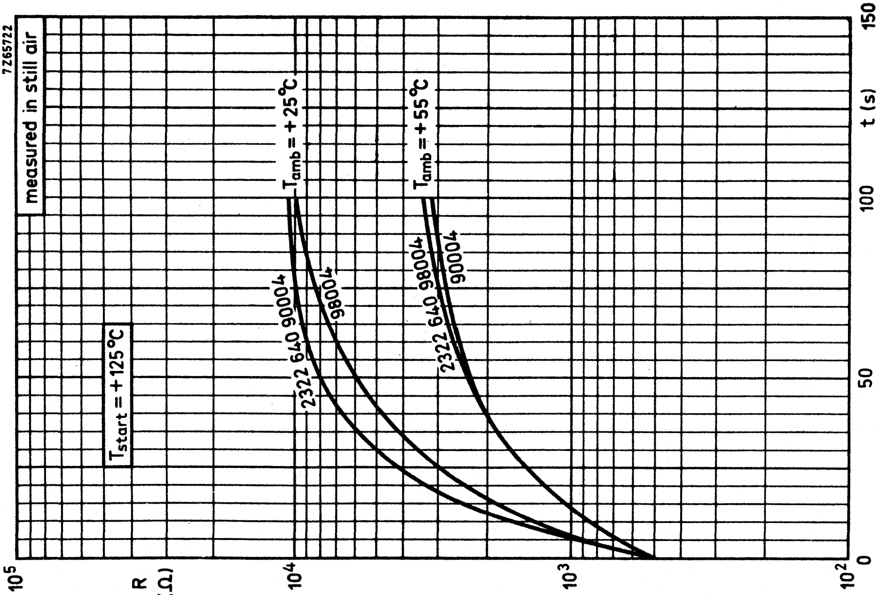


Fig. 5 Typical resistance/time (cooling) characteristics.

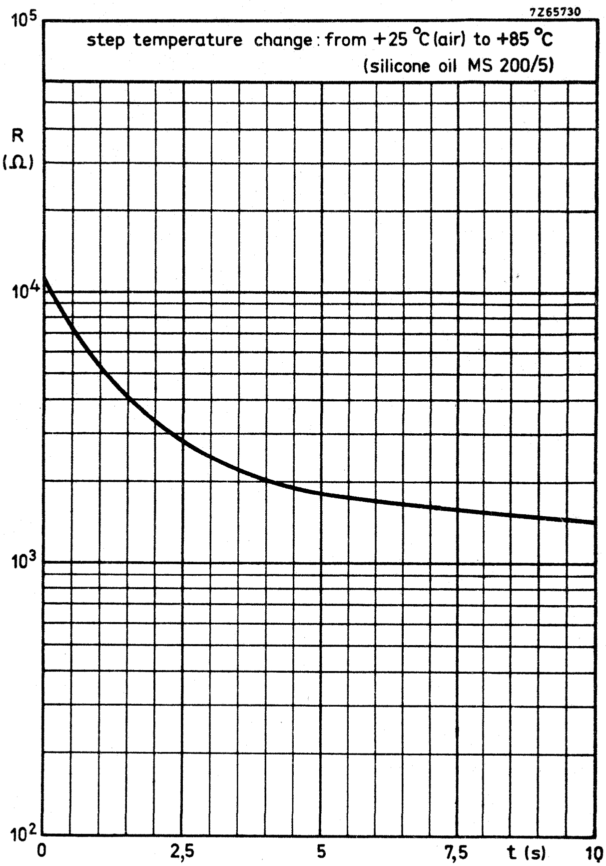


Fig. 7 Typical resistance/response time characteristics.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

Type 2322 640 90004: 500 pieces per box (cardboard).
Type 2322 640 98004: 400 pieces per box (cardboard).

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

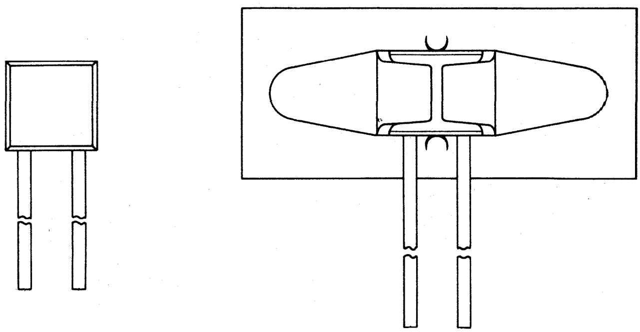
test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +100 °C
Cold at −55 °C	A	1000 h	±3	±3
Storage at +25 °C	H	1000 h	±3	±3
Dry heat at +125 °C	B	1000 h	±5	±5
Thermal shock −25 to +125 °C (slow)	Na	5 cycles	±3	±3
Thermal cycle −25 to +125 °C (fast)		1000 cycles (3)	±3	±3
Damp heat at +40 °C	Ca	1000 h	±5	±5
Dissipation in damp heat		336 h	±5	±5
Maximum dissipation at T_{amb} = +25 °C		1000 h	±5	±5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	(1)	
Bending 5 N	Ub	2 times	(1)	
Soldering	T			
Solderability at max 240 °C	par.3.2.3	3 to 4 s	(2)	
Resistance to heat at 260 ± 5 °C	Tb	10 ± 1 s	±2	±2
Impact				
Free fall	Ed	2 falls	(4)	

(1) Leads should neither come loose nor break.
(2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
(3) Cycle time: 30 min on/30 min off.
(4) No visual defects will be stated.

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/°C
when mounted on a heat-sink	17,5	20,5	mW/°C
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

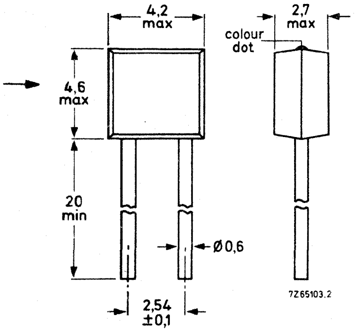
For high temperature control.

DESCRIPTION

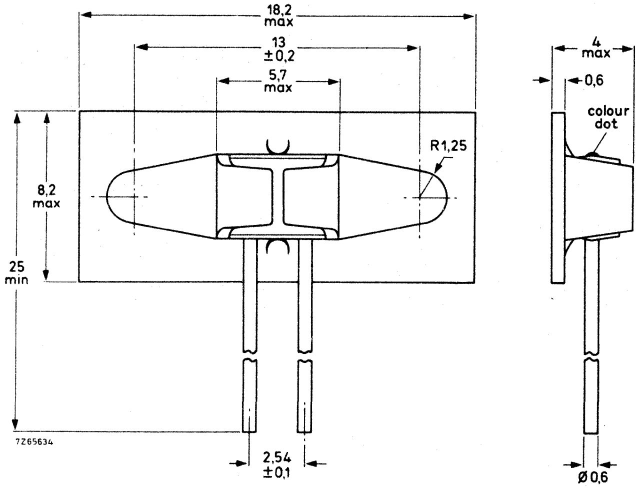
Moulded disc thermistor with negative temperature control and with two solid tinned copper wires. The body colour is red. ←
The thermistor 2322 640 98005 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions (mm)



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.

ELECTRICAL DATA

Unless otherwise specified, measured 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	%/°C
Maximum dissipation	0,25	0,25	W
Dissipation factor	7	9,5	mW/°C
when mounted on a heatsink *	17,5	20,5	mW/°C
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/°C
of complete component	0,13	0,31	J/°C
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 (ϕ1,3 mm).

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

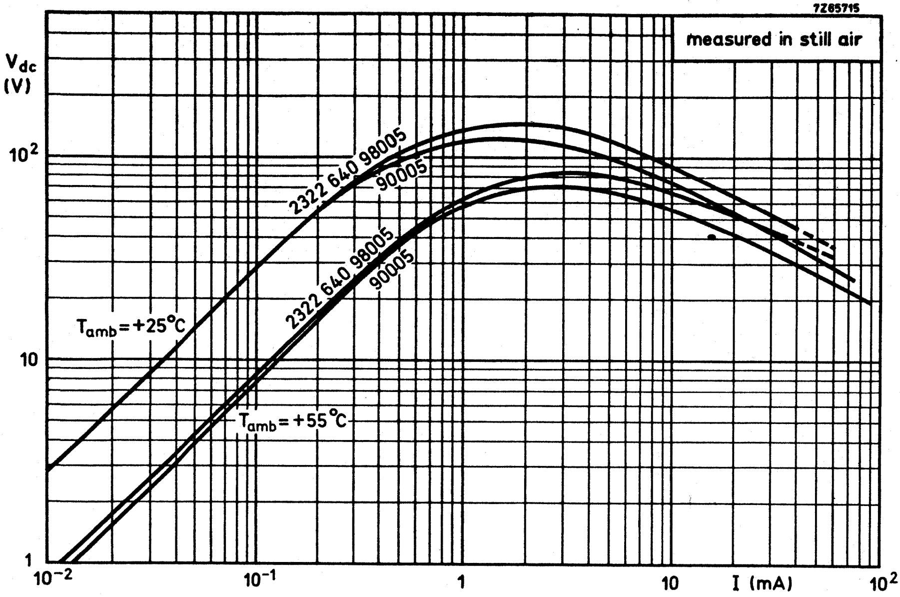


Fig. 2 Typical voltage/current characteristics.

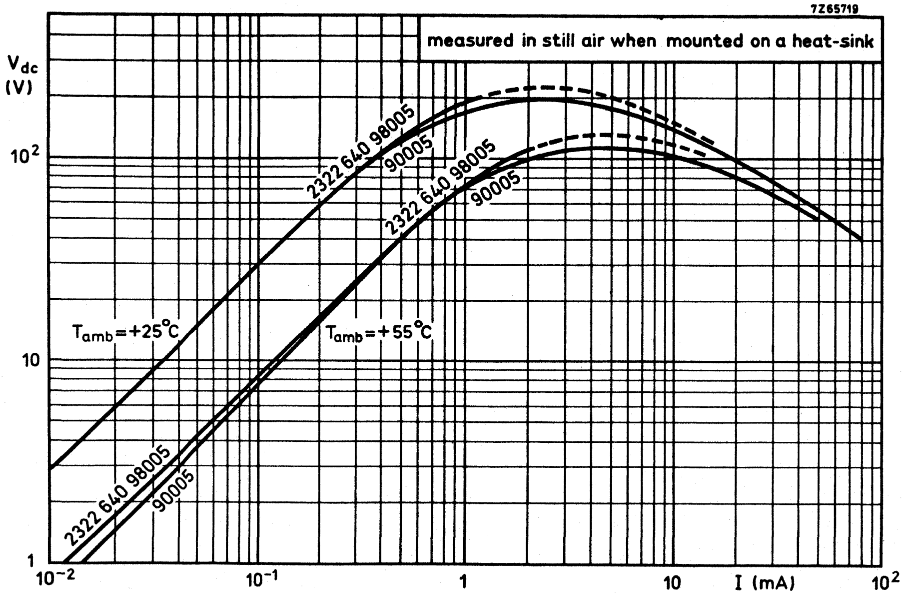


Fig. 3 Typical voltage/current characteristics.

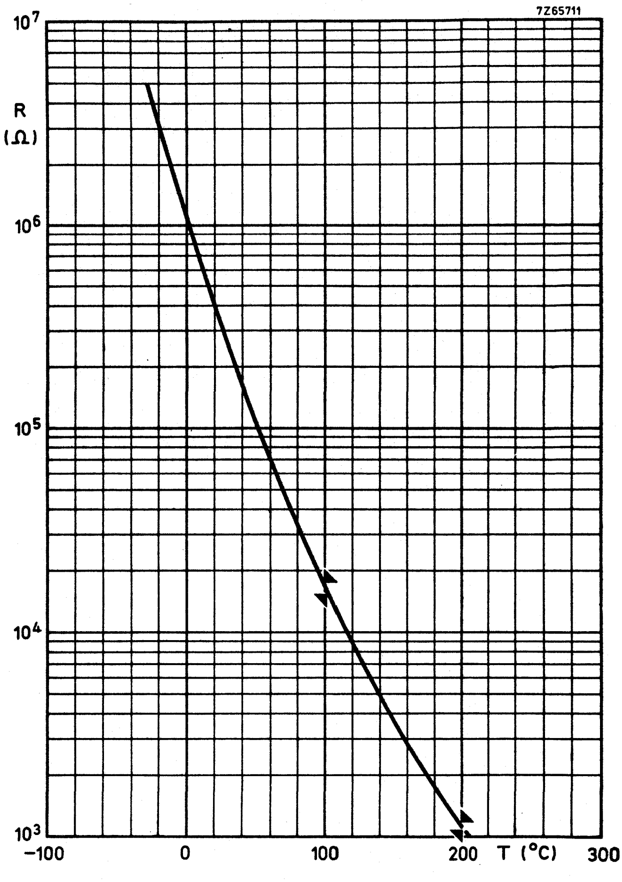


Fig.4 Typical resistance/temperature characteristics.

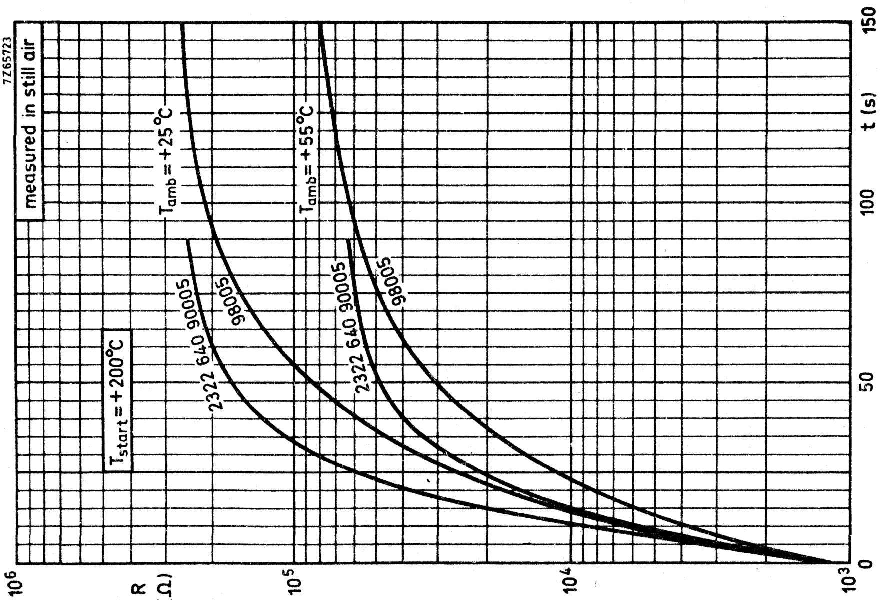


Fig.5 Typical resistance/time (cooling) characteristics.

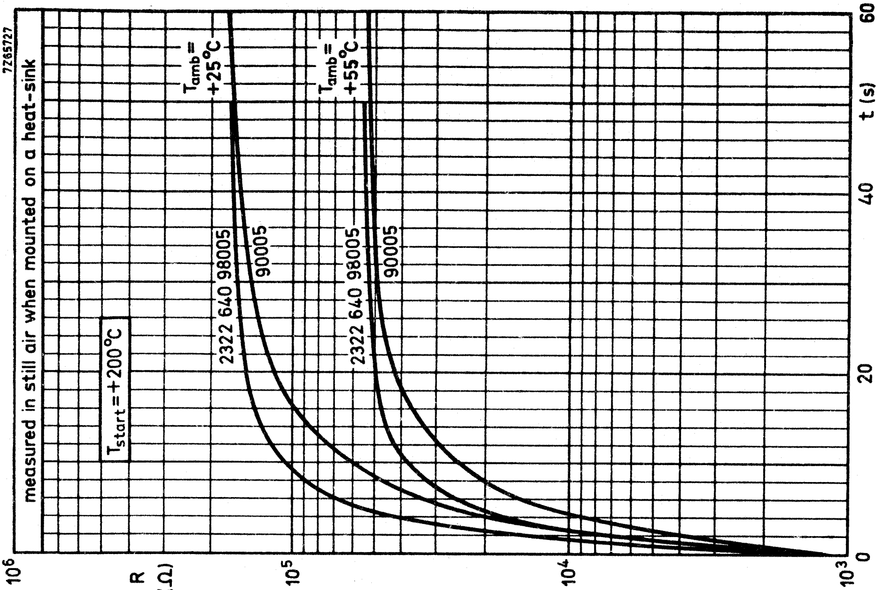


Fig.6 Typical resistance/time (cooling) characteristics.

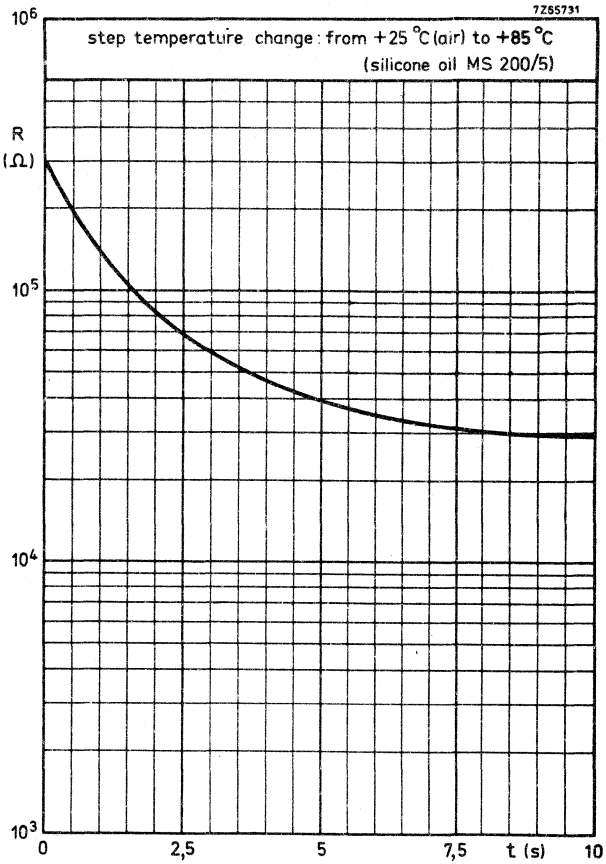


Fig. 7 Typical resistance/response time characteristics.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical

PACKAGING

Type 2322 640 90005: 500 pieces per box (cardboard).
Type 2322 640 98005: 400 pieces per box (cardboard).

NTC THERMISTORS

QUICK REFERENCE DATA

Resistance value	
at +25 °C	12 kΩ ± 7%
at +90 °C	1,3 kΩ ± 5%
$B_{25/85}$-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	−25 to +110 °C continuously to +130 °C for max. 24 h
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, provided with two tinned brass spade connectors.

MECHANICAL DATA

Dimensions in mm

Outlines

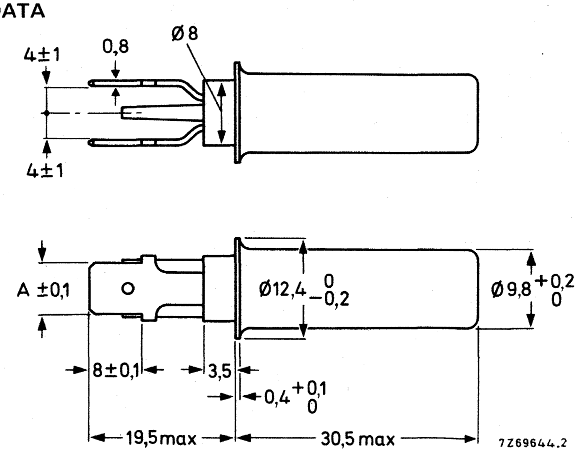


Fig. 1.

A = 6,3 mm for thermistor 2322 640 90007
A = 2,8 mm for thermistor 2322 640 90011

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	3700 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 max. +110 °C continuously max. +130 °C max. 24 h
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

* 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.

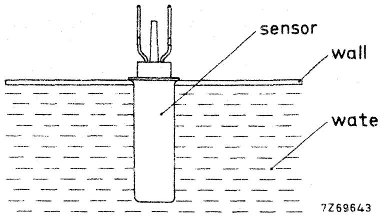


Fig. 2.

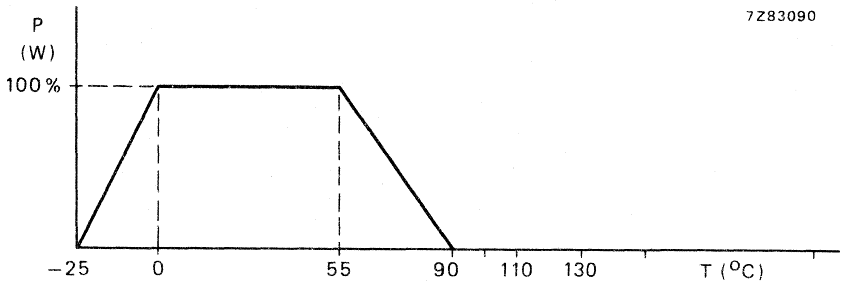


Fig. 3 Power derating with ambient temperature.

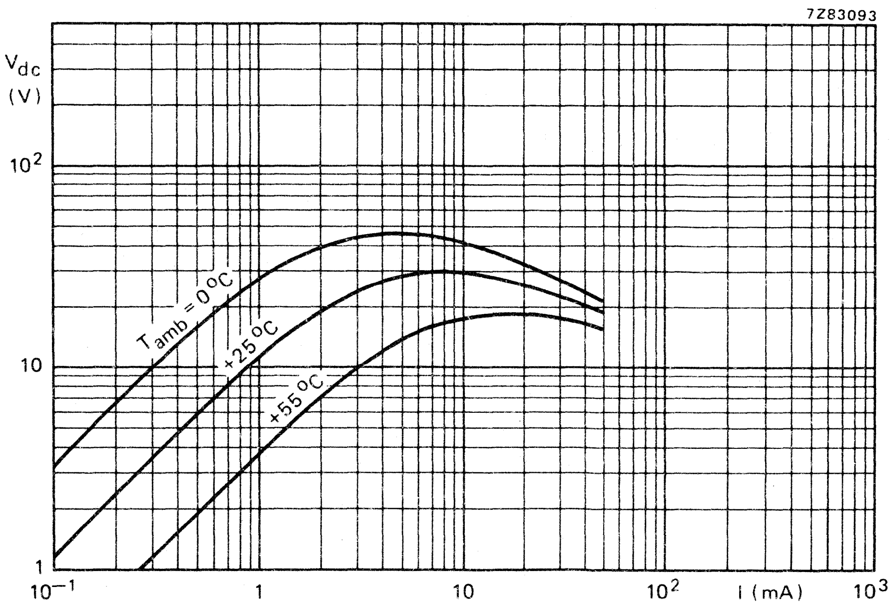


Fig. 4 Typical voltage/current characteristic measured in still air.

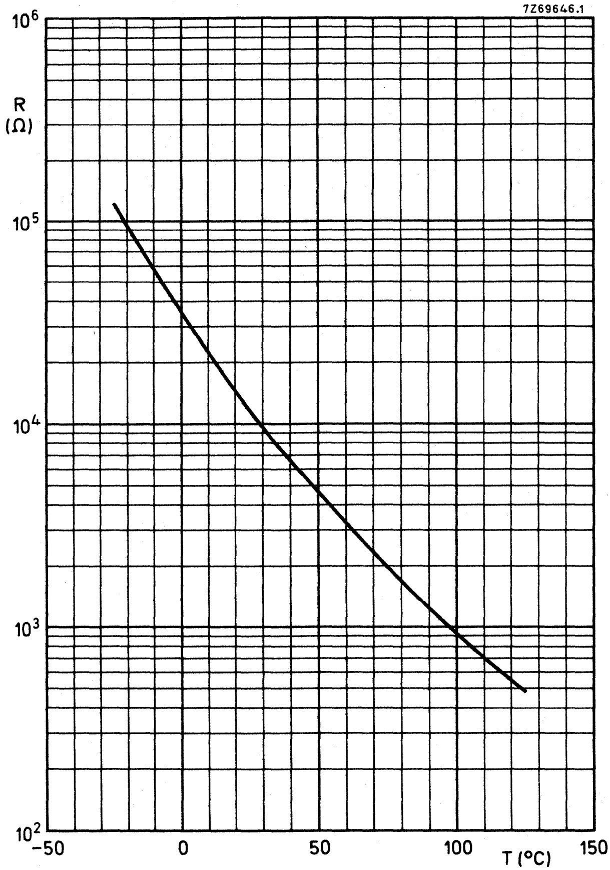


Fig. 5 Typical resistance/temperature characteristic.

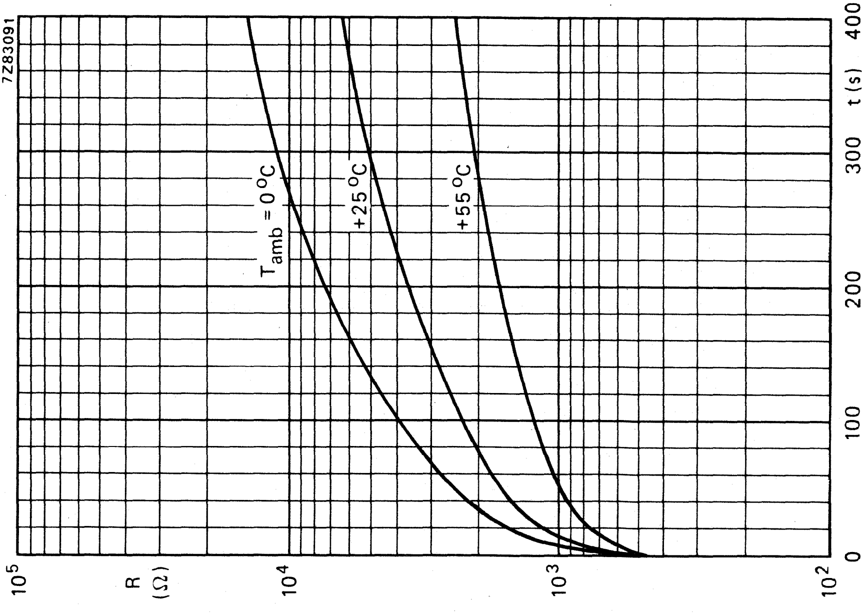


Fig. 6 Typical resistance/time (cooling) characteristics measured in still air, T_{start} = +125 °C.

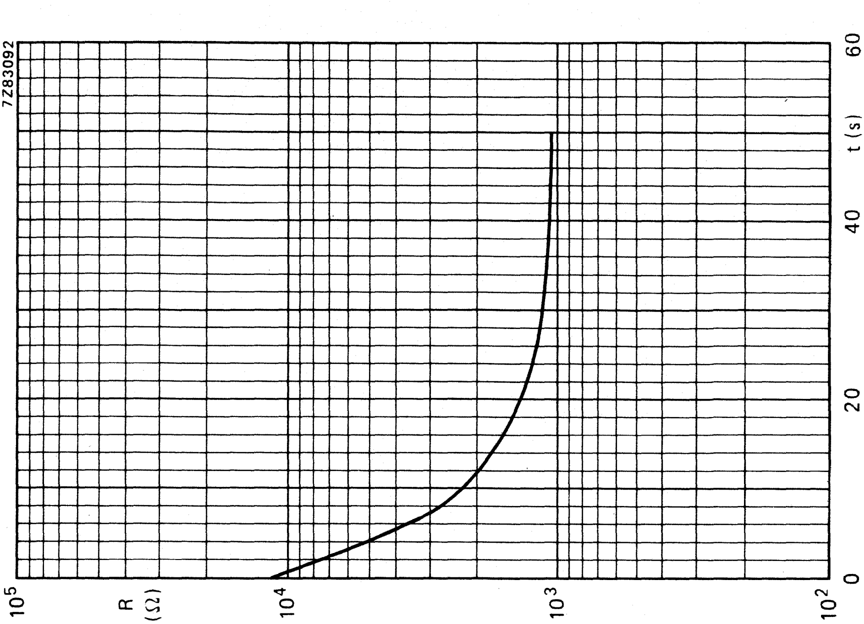


Fig. 7 Typical resistance/response time characteristic. Temperature step from still air of +25 °C to still water of +100 °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +90 °C
Cold at −25 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat				
at +110 °C	B	1000 h	± 5	± 5
at +130 °C		24 h	± 3	± 3
Thermal shock −25 to +110 °C	Na	5 cycles	± 3	± 3
Storage in water of +25 °C	note 1	48 h	± 5	± 5
Dissipation in damp heat		1000 h	± 5	± 5
Maximum dissipation at T_{amb} = +55 °C		1000 h	± 5	± 5
Cycle test	note 2	10 000 cycles	± 5	± 5
	note 3	50 cycles	± 5	± 5
Robustness of terminations	U			
Tensile strength 50 N	Ua	10 s	note 4	
Vibration	Fc		note 5	
Impact	E			
Bump	Eb		note 5	
Free fall	Ed	2 falls	note 5	

Notes
1. One cubic centimeter detergent per liter water.
2. 1 min in oil of 14 °C and 1 min in oil of 105 °C.
3. 1 min in oil of 14 °C and 1 min in oil of 130 °C.
4. Terminals should neither come loose nor break.
5. Neither electrical nor visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 % Electrical
A.Q.L. 1,5 % Mechanical
A.Q.L. 0,25% Inoperatives

PACKAGING

50 pieces per box (cardboard).

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/°C
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 provided with two solid tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

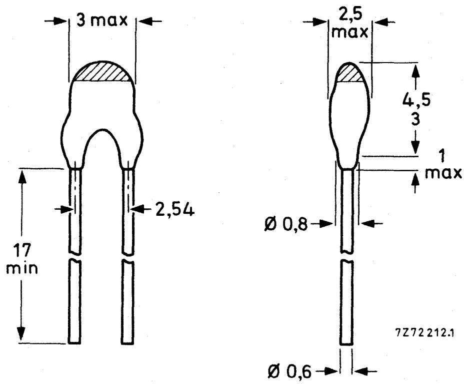


Fig.1

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

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 %/°C approx.
Maximum dissipation at T_{amb} = +55 °C	*	0,25 W
Dissipation factor	*	7,5 mW/°C approx.
Thermal time constant (τ_c)	*	19 s approx.
Heat capacity	*	0,135 J/°C approx.
Operating temperature range		
at zero power		−55 to +85 °C
at maximum power		−55 to +55 °C

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

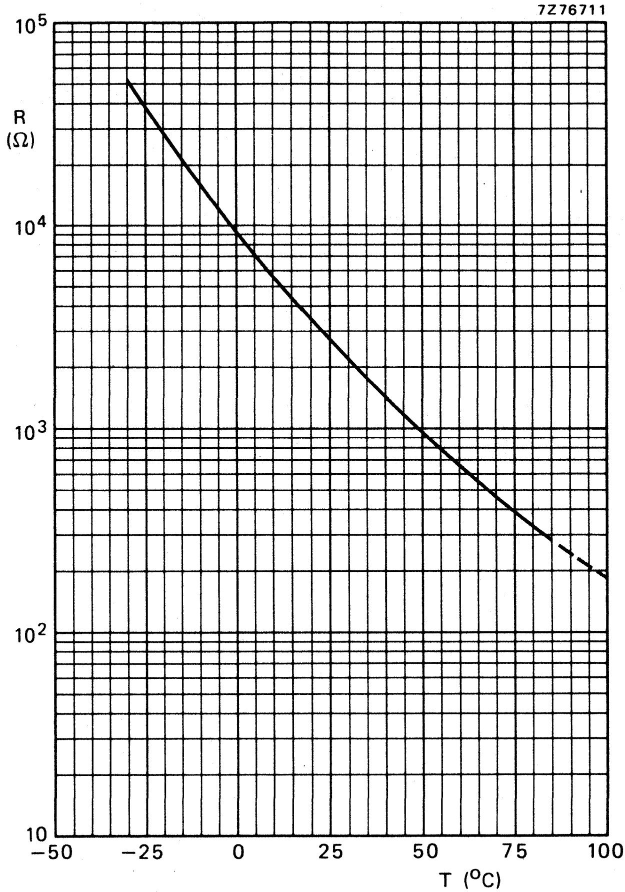


Fig.2 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	procedure	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold	A	1000 h −25 °C	±3	±2
Storage	H	1000 h +25 °C	±3	±1
Dry heat	B	1000 h +85 °C	±5	±2
Thermal shock	Na	5 cycles −25 to +85 °C	±3	±2
Damp heat	Ca	1000 h +40 °C	±5	±3
Combined cycle test	19 B	NF C20−619	±5	±3
Maximum dissipation		1000 h, T_{amb} = +55 °C	±5	±2
Robustness of terminations	U			
Tensile strength	Ua	10 N 10 s	(1)	
Bending	Ub	5 N 2 times	(1)	
Soldering	T			
Solderability	par.3.2.3	max 240 °C, 3 to 4 s	(2)	
Resistance to heat	Tb	260 ± 5 °C, 10 ± 1 s	ΔR_{25} ±2%	ΔB ±2%
Impact				
Free fall	Ed	2 falls of 1 m	no visual defects	
Inflammability		needle flame 20 s	no burning 15 s after removal of flame	
Resistance to solvents		ICI cleaning process for p.c.b.:		
		Arklone P	no influence	
		Arklone L, boiling	slight softening after 10 min	
		Freon TF	no influence	

(1) Leads should neither come loose nor break.
(2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4%, minor defects – Physical

PACKAGING

500 pieces per box (cardboard).

NTC THERMISTORS
moulded

QUICK REFERENCE DATA

	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
Maximum dissipation	0,25	0,25	W
Dissipation factor	6,7	9	mW/°C
when mounted on a heatsink	16	21	mW/°C
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

Black moulded disc thermistor with negative temperature coefficient and with two solid tinned copper wires. The thermistor 2322 640 98013 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions in mm

Outlines

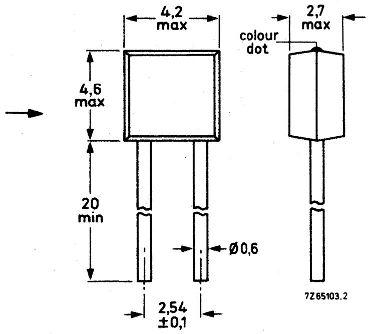


Fig.1 Type 2322 640 90013.

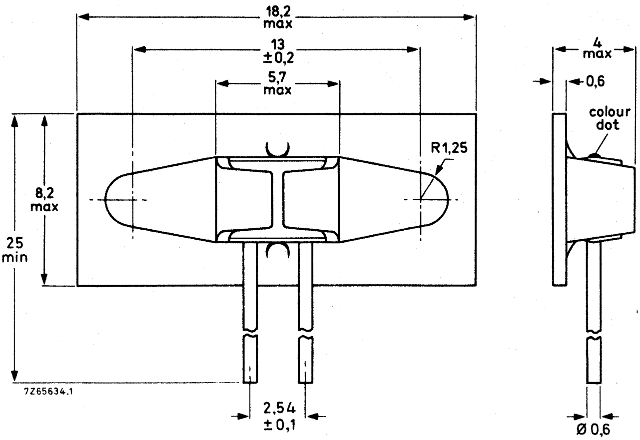


Fig.2 Type 2322 640 98013 with metal strip for mounting.

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

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	%/°C
Maximum dissipation at T_{amb} = +55 °C	0,25	0,25	W
Dissipation factor *	6,7	9	mW/°C
when mounted on a heatsink **	16	21	mW/°C
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/°C
of complete component *	0,11	0,29	J/°C
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

* Measured in the measuring set described in the French norm NF C93−271.

** As *, but the thermistor mounted on a heatsink of 100 cm^2, thickness 1,5 mm.

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

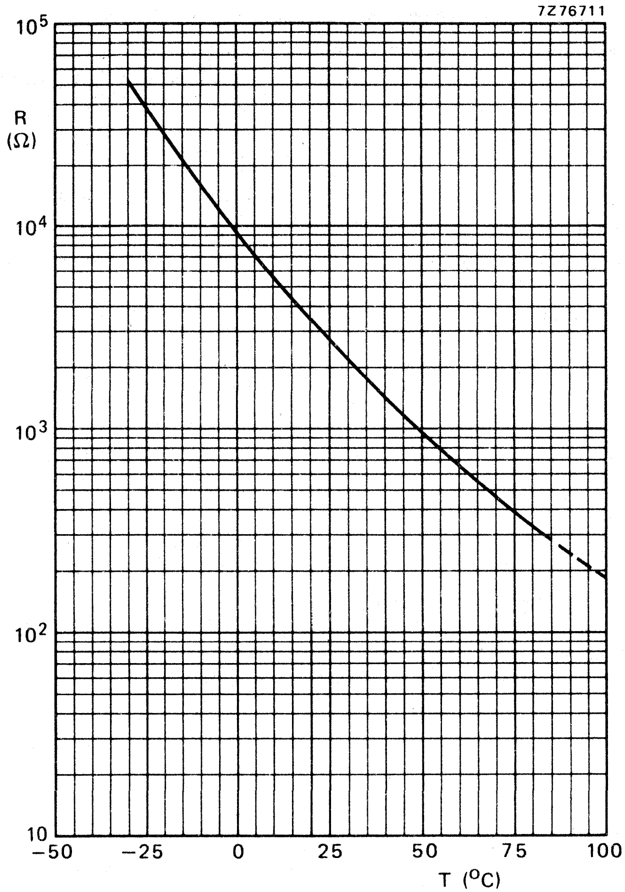


Fig.3 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	procedure	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta R_{-20}}{R_{-20}}$ (%)
Cold	A	1000 h −25 °C	±3	±3
Storage	H	1000 h +25 °C	±3	±3
Dry heat	B	1000 h +85 °C	±5	±5
Thermal shock (slow)	Na	5 cycles −25 to +85 °C	±3	±3
Thermal cycle (fast)		1000 cycles −25 to +85 °C 30 min on/20 min off	±3	±3
Damp heat	Ca	1000 h +40 °C	±5	±5
Dissipation in damp heat		336 h	±3,5	±3,5
Maximum dissipation		1000 h +55 °C	±5	±5
Robustness of terminations	U			
Tensile strength	Ua	10 N 10 s	(1)	
Bending	Ub	5 N 2 times	(1)	
Soldering	T			
Solderability	par.3.2.3	max 240 °C, 3 to 4 s	(2)	
Resistance to heat	Tb	260 ± 5 °C, 10 ± 1 s	ΔR_{25} ± 2%	ΔR_{-20} ± 2%
Impact				
Free fall	Ed	2 falls of 1 m	no visual defects	
Inflammability	22	CCTU 01–01A		

(1) Leads should neither come loose nor break.
(2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4%, minor defects – Physical

PACKAGING

Type 2322 640 90013: 500 pieces per box (cardboard).
Type 2322 640 98013: 400 pieces per box (cardboard).

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/°C
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 provided with two solid tinned copper wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Dimensions in mm

Outlines

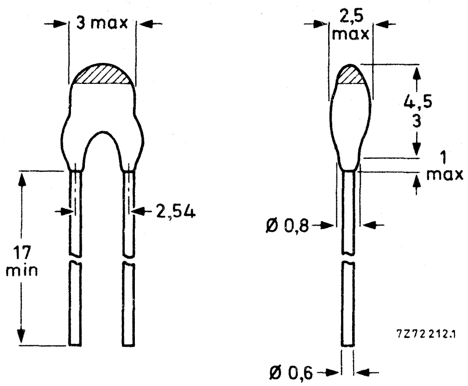


Fig.1

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

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 approx.
Temperature coefficient at +25 °C	−4,5 %/°C approx.
Maximum dissipation at T_{amb} = +55 °C *	0,25 W
Dissipation factor *	7,5 mW/°C approx.
Thermal time constant (τ_c) *	19 s approx.
Heat capacity *	0,135 J/°C approx.
Operating temperature range	
at zero power	−55 to +85 °C
at maximum power	−55 to +55 °C

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

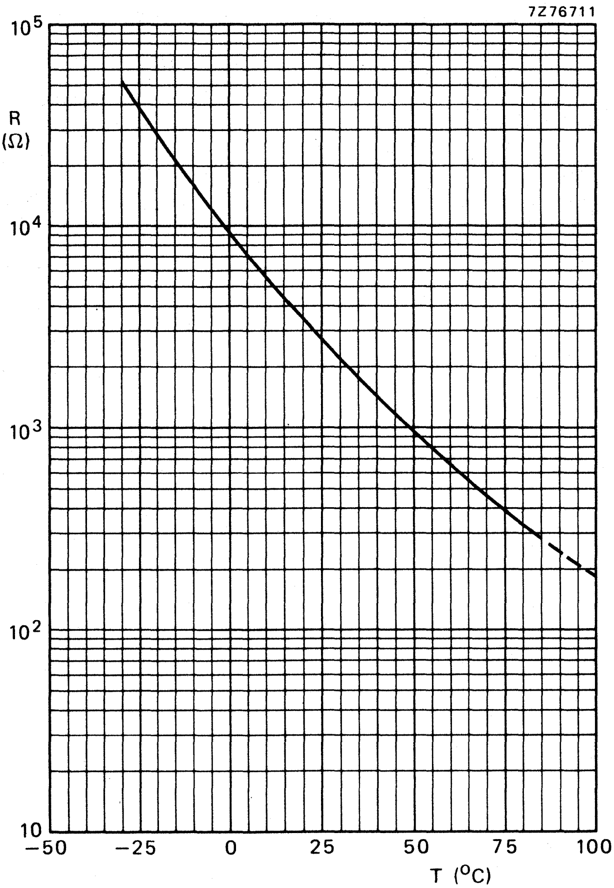


Fig.2 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	procedure	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold	A	1000 h −25 °C	±3	±2
Storage	H	1000 h +25 °C	±3	±1
Dry heat	B	1000 h +85 °C	±5	±2
Thermal shock	Na	5 cycles −25 to +85 °C	±3	±2
Damp heat	Ca	1000 h +40 °C	±5	±3
Combined cycle test	19 B	NF C20–619	±5	±3
Maximum dissipation		1000 h, T_{amb} = +55 °C	±5	±2
Robustness of terminations	U			
Tensile strength	Ua	10 N 10 s	(1)	
Bending	Ub	5 N 2 times	(1)	
Soldering	T			
Solderability	par.3.2.3	max 240 °C, 3 to 4 s	(2)	
Resistance to heat	Tb	260 ± 5 °C, 10 ± 1 s	ΔR_{25} ±2%	ΔB ±2%
Impact				
Free fall	Ed	2 falls of 1 m	no visual defects	
Inflammability		needle flame 20 s	no burning 15 s after removal of flame	
Resistance to solvents		ICI cleaning process for p.c.b.:		
		Arklone P	no influence	
		Arklone L, boiling	slight softening after 10 min	
		Freon TF	no influence	

(1) Leads should neither come loose nor break.
(2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4%, minor defects - Physical

PACKAGING

500 pieces per box (cardboard).

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/°C
when mounted on a heatsink	16	21	mW/°C
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 colour black.
The thermistor 2322 640 98015 is provided with a metal strip for mounting.

MECHANICAL DATA

Dimensions in mm

Outlines

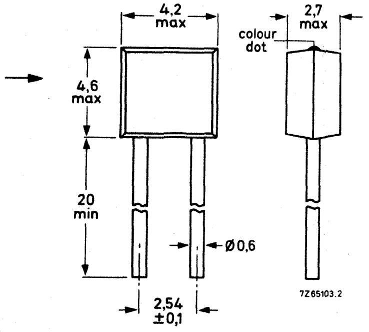


Fig.1 Type 2322 640 90015.

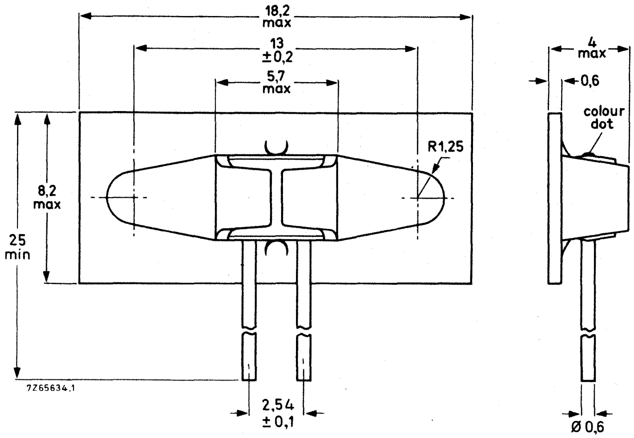


Fig.2 Type 2322 640 98015 with metal strip for mounting.

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

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	%/°C
Maximum dissipation at T_{amb} = +55 °C	0,25	0,25	W
Dissipation factor *	6,7	9	mW/°C
when mounted on a heatsink **	16	21	mW/°C
Thermal time constant (τ_c) *	17	32	s
when mounted on a heatsink **	6	3	s
Heat capacity			J/°C
of ceramic	0,009	0,009	J/°C
of complete component *	0,11	0,29	J/°C
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

* Measured in the measuring set described in the French norm NF C93–271.

** As *, but the thermistor mounted on a heatsink of 100 cm^2, thickness 1,5 mm.

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

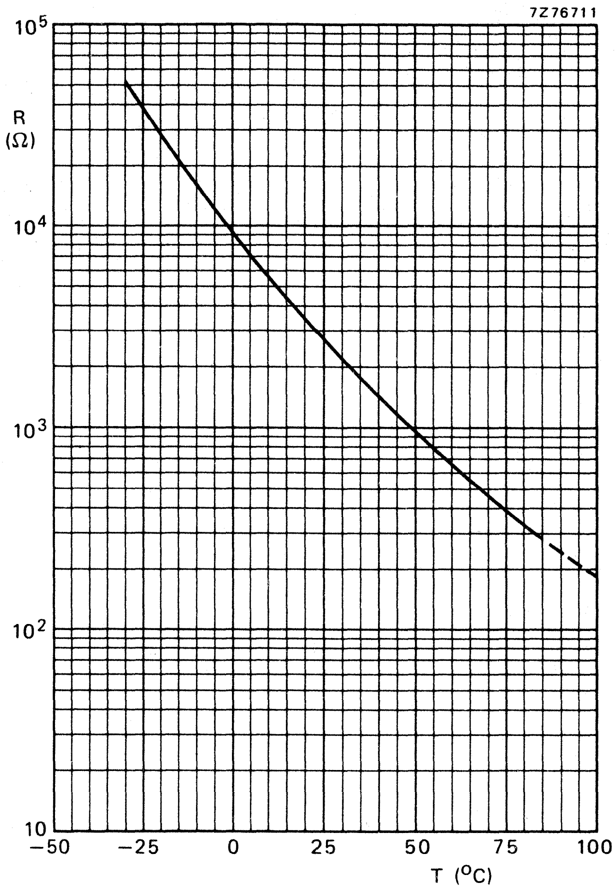


Fig.3 Typical resistance/temperature characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	procedure	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta R_{-20}}{R_{-20}}$ (%)
Cold	A	1000 h −25 °C	±3	±3
Storage	H	1000 h +25 °C	±3	±3
Dry heat	B	1000 h +85 °C	±5	±5
Thermal shock (slow)	Na	5 cycles −25 to +85 °C	±3	±3
Thermal cycle (fast)		1000 cycles −25 to +85 °C 30 min on/20 min off	±3	±3
Damp heat	Ca	1000 h +40 °C	±5	±5
Dissipation in damp heat		336 h	±3,5	±3,5
Maximum dissipation		1000 h +55 °C	±5	±5
Robustness of terminations	U			
Tensile strength	Ua	10 N 10 s	(1)	
Bending	Ub	5 N 2 times	(1)	
Soldering	T			
Solderability	par.3.2.3	max 240 °C, 3 to 4 s	(2)	
Resistance to heat	Tb	260 ± 5 °C, 10 ± 1 s	ΔR_{25} ±2%	ΔR_{-20} ±2%
Impact				
Free fall	Ed	2 falls of 1 m	no visual defects	
Inflammability	22	CCTU 01–01A		

(1) Leads should neither come loose nor break.
(2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

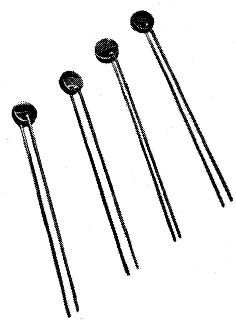
A.Q.L. 1%, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4%, minor defects – Physical

PACKAGING

Type 2322 640 90015: 500 pieces per box (cardboard).
Type 2322 640 98015: 400 pieces per box (cardboard).

NTC THERMISTORS
disc

RZ 27317-5



QUICK REFERENCE DATA	
Resistance values at 25 °C	3.3 Ω to 330 kΩ according to E6-series
B-values	between 2600 and 4700 K
Max. dissipation at T_{amb} = 55 °C	0.5 W
Operating temperature range at zero power	−25 to +125 °C
Dissipation factor	8 to 9 mW/°C
Thermal time constant	20 to 30 s

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

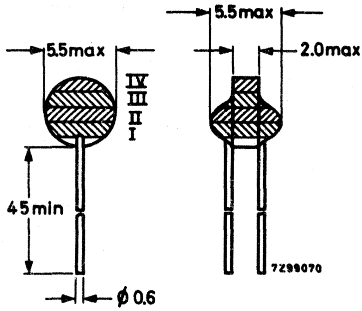


Fig. 1

Marking

The thermistors are marked with three bands showing their resistance value (R_{25}) in colour code; the types with a tolerance on R_{25} of 10% also have a silver band, those with a tolerance on R_{25} of 5% a gold band (see Fig. 1).

Weight 0.5 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. 240 °C, max. 4 s

ELECTRICAL DATA

Tolerance on resistance value at 25 °C (R_{25})	± 20, ± 10 and ± 5%
Tolerance on B-value	± 5%
Max. dissipation at 55 °C	0.5 W
Operating temperature range at zero power	−25 to +125 °C

R_{25} (Ω)	$B_{25/85}$ 1) (°K)	dissipation factor approx. (mW/degC)	thermal time constant approx. (s)	colour code (see Marking) I	II	III	catalogue number 2)
3.3	2600	9	30	orange	orange	gold	2322 642 1.338
4.7	2665	9	30	yellow	violet	gold	1.478
6.8	2730	9	30	blue	grey	gold	1.688
10	2800	9	30	brown	black	black	1.109
15	2870	9	30	brown	green	black	1.159
22	2935	9	25	red	red	black	1.229
33	3010	9	25	orange	orange	black	1.339
47	3070	9	25	yellow	violet	black	1.479
68	3135	8	25	blue	grey	black	1.689
100	3200	8	25	brown	black	brown	1.101
150	3280	8	25	brown	green	brown	1.151
220	3350	8	25	red	red	brown	1.221
330	3440	8	25	orange	orange	brown	1.331
470	3520	8	25	yellow	violet	brown	1.471
680	3600	8	25	blue	grey	brown	1.681
1000	3680	8	25	brown	black	red	1.102
1500	3775	8	25	brown	green	red	1.152
2200	3915	8	25	red	red	red	1.222
3300	4070	8	25	orange	orange	red	1.332
4700	4200	8	25	yellow	violet	red	1.472
6800	4300	8	25	blue	grey	red	1.682
10000	4400	8	25	brown	black	orange	1.103
15000	4375	8.5	25	brown	green	orange	1.153
22000	4200	8.5	25	red	red	orange	1.223
33000	4250	8.5	25	orange	orange	orange	1.333
47000	4325	8.5	25	yellow	violet	orange	1.473
68000	4375	8.5	25	blue	grey	orange	1.683
100000	4400	8.5	25	brown	black	yellow	1.104
150000	4600	8.5	25	brown	green	yellow	1.154
220000	4650	8.5	25	red	red	yellow	1.224
330000	4700	8.5	25	orange	orange	yellow	1.334

1) B-value is subject to change
2) 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},
3 for a tolerance of 5% on R_{25}.

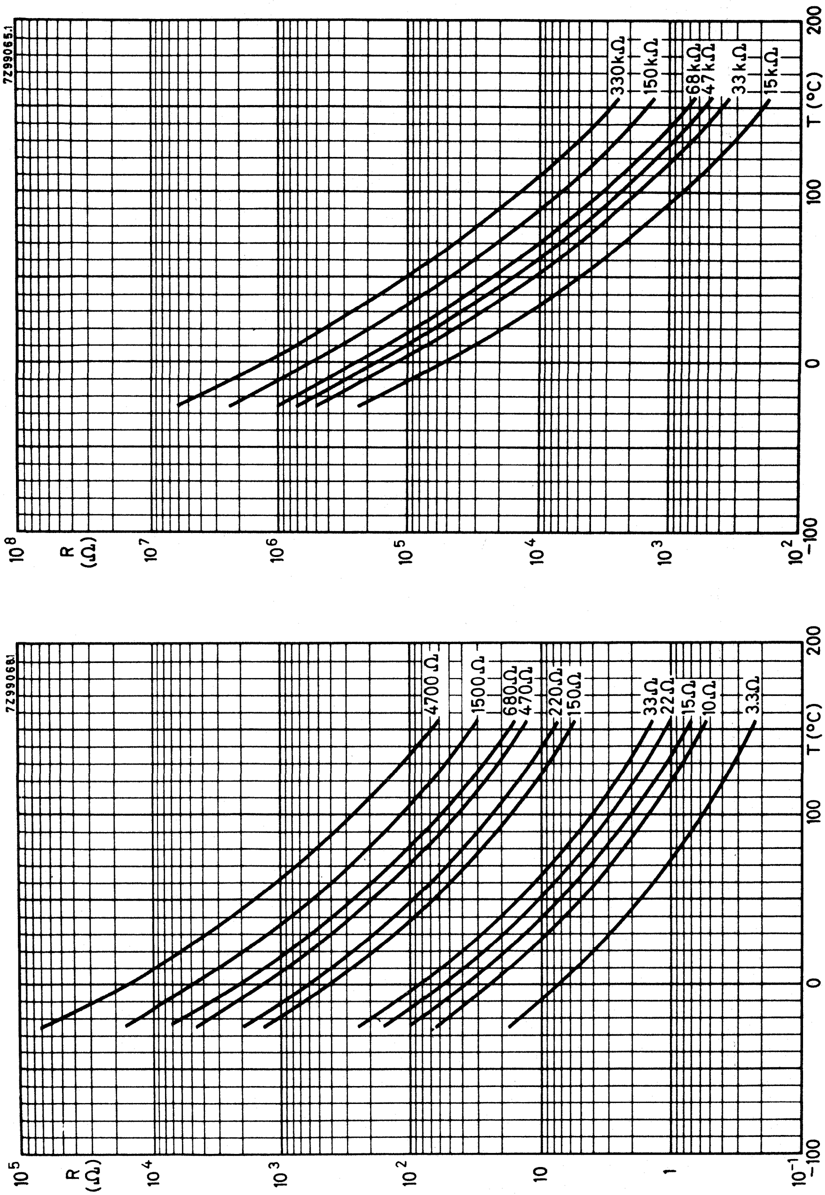
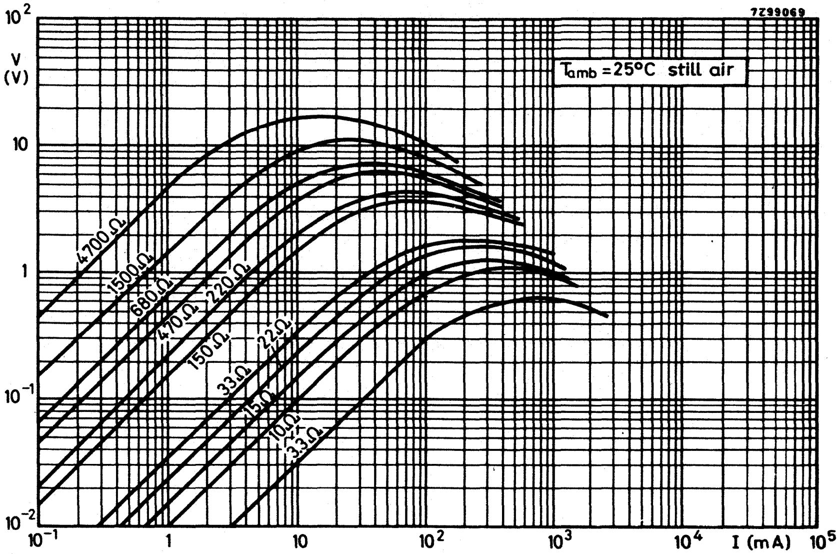
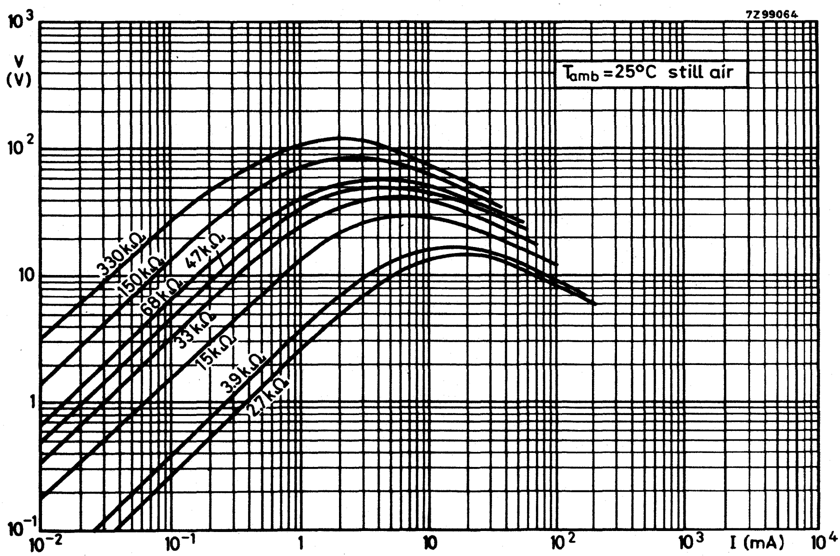


Fig.2 a and b. Resistance/temperature characteristics

Fig.3 a and b. Voltage/current characteristics





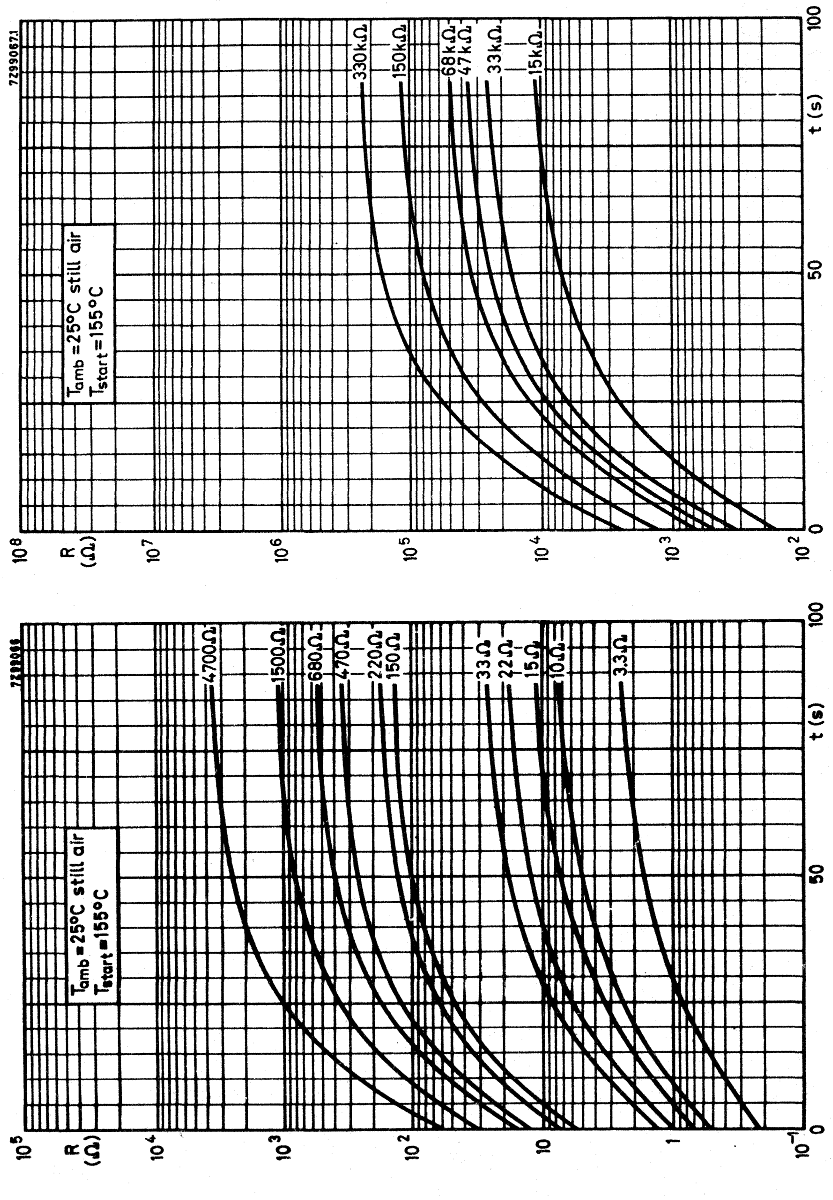


Fig. 4 a and b. Resistance/time (Cooling) characteristics

TESTS AND REQUIREMENTS

According to I.E.C. publication 68

tests	I.E.C. 68 test method	duration	requirements ΔR/R (%)	ΔB/B (%)
Storage at +25 ±10 °C	H	1000 h	± 3	± 1
Dry heat at +125 °C	B	1000 h	± 5	± 2
Thermal shock −25 to +125 °C	Na	5 cycles	± 3	± 2
Damp heat	C	1000 h	± 5	± 3
Max. dissipation at T_{amb} = +55 °C		1000 h	± 5	± 2
Robustness of terminations				
Tensile strength 10 N	Ua	10 s	*)	
Bending 5 N	Ub	2 times	*)	
Soldering	T			
Solderability at 230 °C	Par.3.2.3	3 to 4 s	**)	
Resistance to heat at 230 °C	Par.3.2.4	3 to 4 s	± 2	± 2

*) Leads should neither come loose nor break
**) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects-Electrical
A.Q.L. 1.5 %, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

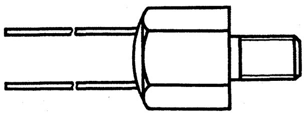
PACKAGING

250 pieces per box (cardboard)

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	2600 to 4700 °K
Maximum dissipation	0,5 W
Dissipation factor	25 mW/°C
Thermal time constant	20 s
Operating temperature range	
at zero power	-25 to + 100 °C
at maximum power	0 to + 55 °C



APPLICATION

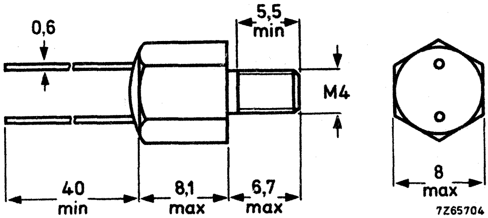
Suitable for all kinds of applications, especially when a good insulation and/or a good thermal contact with the chassis is required.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

The resistance value at + 25 °C (according to table) is printed on the stud in code.

Weight

1,5 g approx.

Mounting

By means of an 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

ELECTRICAL DATA

Maximum dissipation	0,5 W
Dissipation factor *)	25 mW/°C
Thermal time constant *)	20 s approx.

*) Measurements made with screw mounted on an aluminium heat-sink of 1 dm^2, thickness 1,5 mm, in still air, T_{amb} = +25 °C.

Heat capacity	0,5 J/^{o}C approx.
Operating temperature range	
at zero power	−25 to +100 ^{o}C
at maximum power	0 to +55 ^{o}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

R_{25} (Ω)	$B_{25/85}$-value ± 5% (K)	temperature coefficient at 25 ^{o}C (%/^{o}C)	catalogue number 2322 642 2.... tol. 5%	tol. 10%	tol. 20%
3,3	2600	−2,9	3338	2338	1338
4,7	2665	−3,0	3478	2478	1478
6,8	2730	−3,1	3688	2688	1688
10	2800	−3,2	3109	2109	1109
15	2870	−3,2	3159	2159	1159
22	2935	−3,3	3229	2229	1229
33	3010	−3,4	3339	2339	1339
47	3070	−3,5	3479	2479	1479
68	3135	−3,5	3689	2689	1689
100	3200	−3,6	3101	2101	1101
150	3280	−3,7	3151	2151	1151
220	3350	−3,8	3221	2221	1221
330	3440	−3,9	3331	2331	1331
470	3520	−4,0	3471	2471	1471
680	3600	−4,1	3681	2681	1681
1000	3680	−4,1	3102	2102	1102
1500	3775	−4,3	3152	2152	1152
2200	3915	−4,4	3222	2222	1222
3300	4070	−4,6	3332	2332	1332
4700	4200	−4,7	3472	2472	1472
6800	4300	−4,8	3682	2682	1682
10 000	4400	−5,0	3103	2103	1103
15 000	4375	−4,9	3153	2153	1153
22 000	4200	−4,7	3223	2223	1223
33 000	4250	−4,8	3333	2333	1333
47 000	4325	−4,9	3473	2473	1473
68 000	4375	−4,9	3683	2683	1683
100 000	4400	−5,0	3104	2104	1104
150 000	4600	−5,2	3154	2154	1154
220 000	4650	−5,2	3224	2224	1224
330 000	4700	−5,3	3334	2334	1334

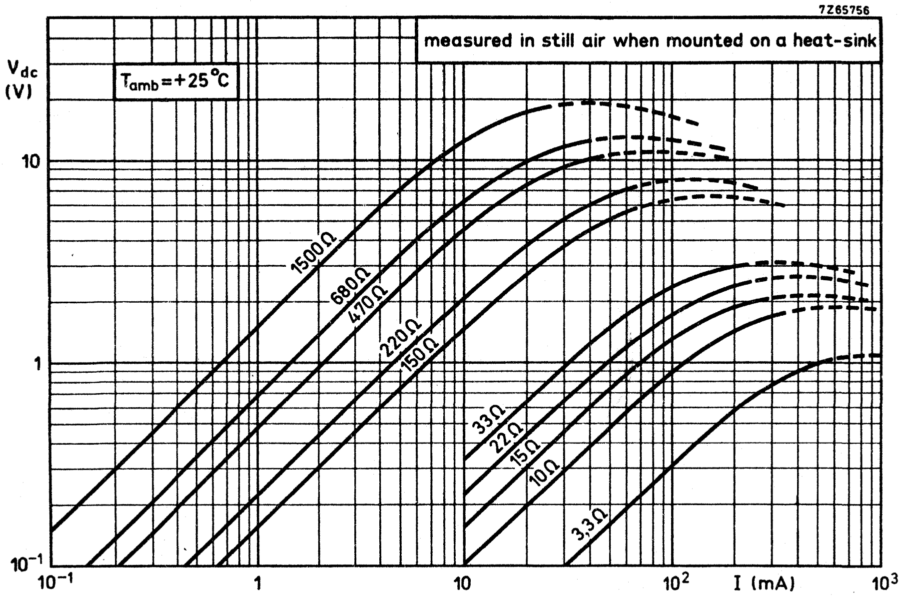


Fig.2 Typical voltage/current characteristics

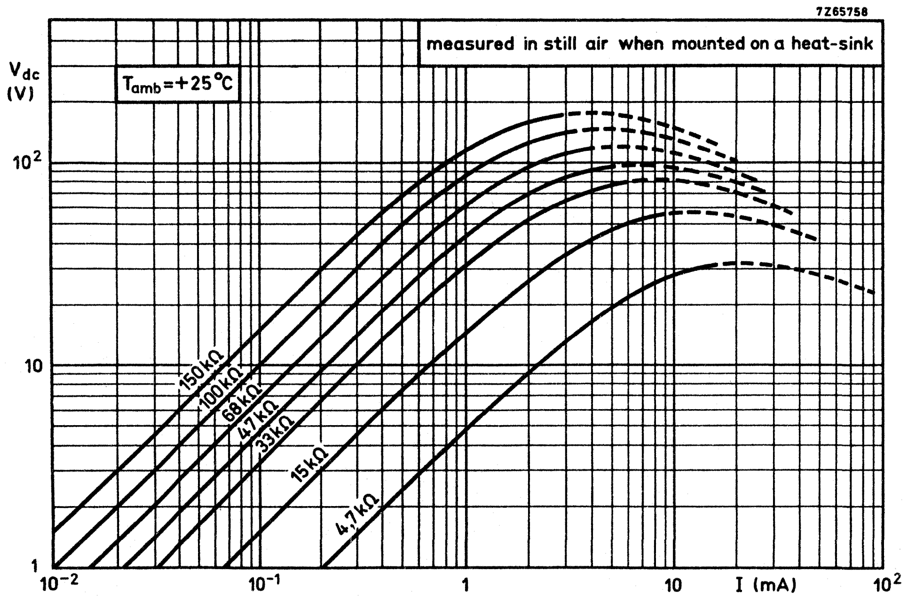


Fig.3 Typical voltage/current characteristics

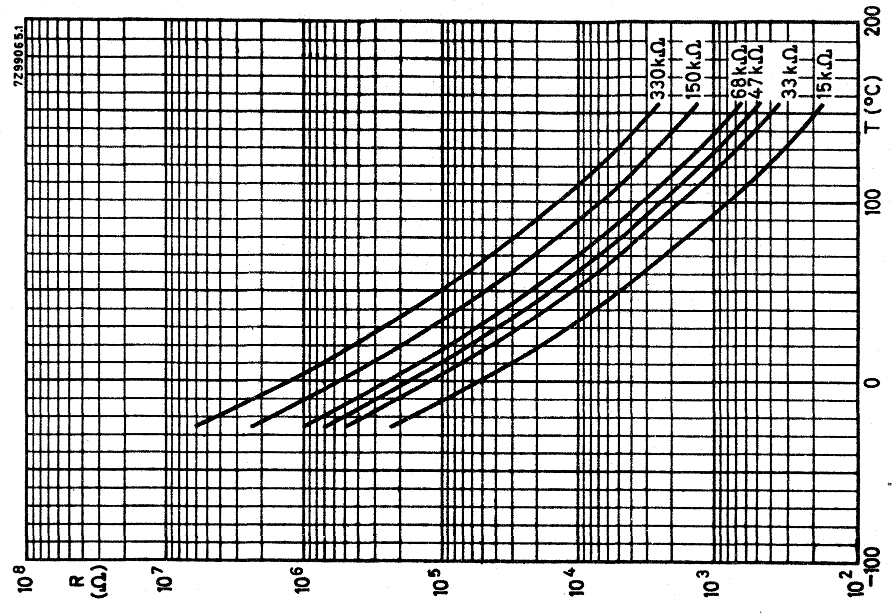


Fig.5 Typical resistance/temperature characteristics

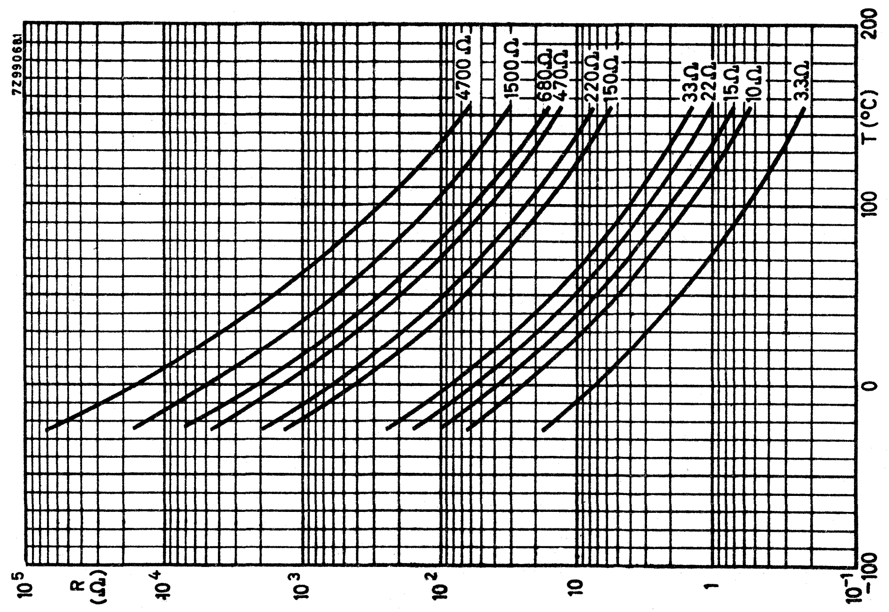


Fig.4 Typical resistance/temperature characteristics

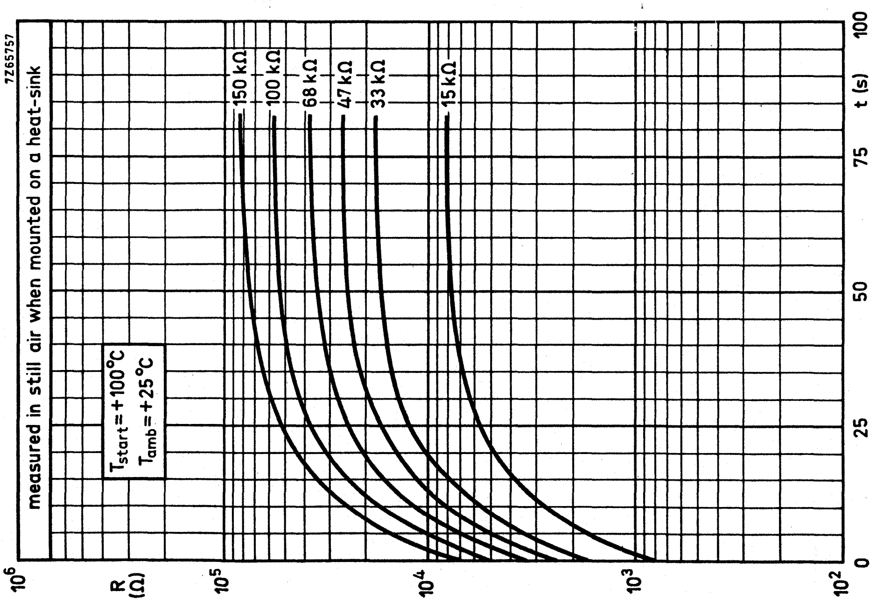


Fig.6 Typical resistance/time(cooling) characteristics

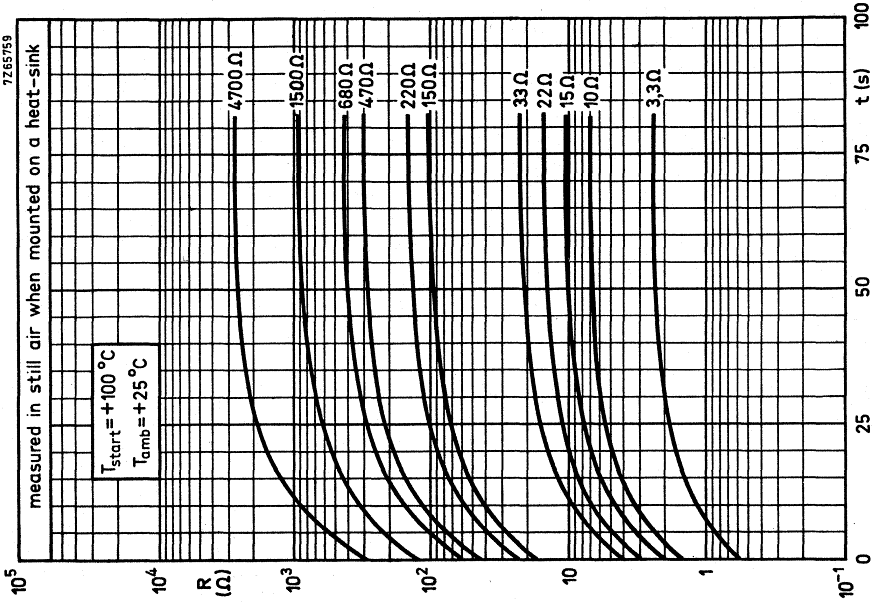


Fig.7 Typical resistance/time (cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	$\frac{\Delta R_{25}}{R_{25}}$ (%)	$\frac{\Delta B}{B}$ (%)
Cold at −25 °C	A	1000 h	±3	±2
Storage at +25 °C	H	1000 h	±3	±1
Dry heat at +100 °C	B	1000 h	±5	±2
Thermal shock −25 to +100 °C	Na	5 cycles	±3	±2
Damp heat	C	1000 h	±5	±3
Max. dissipation		1000 h	±5	±2
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Torque on screw max. 1,2 Nm		once	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3.	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4.	3 to 4 s	±2	±3

1) Leads should neither come loose nor break
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

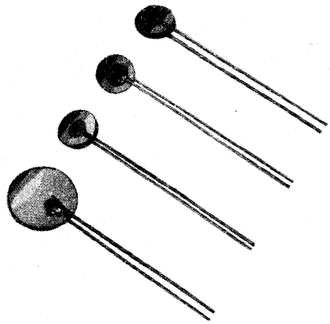
A.Q.L. 1 %, major defects-Electrical
A.Q.L. 1,5%, major defects-Mechanical
A.Q.L. 4 %, minor defects-Physical

PACKAGING

100 pieces per box (cardboard)

NTC THERMISTORS

disc



RZ 27317-8

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/°C	13 mW/°C
Thermal time constant	55 s	120 s

APPLICATION

These discs are suitable for all kinds of applications.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

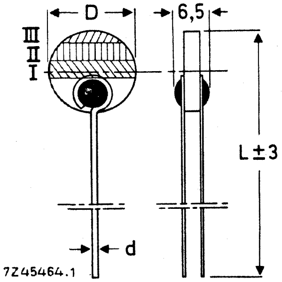


Fig. 1

series	D	L	d
2322 643	9 ±0,5	54	0,6
2322 644	15 ±0,7	58	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.

Weight

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

Mounting

In any position by soldering.

ELECTRICAL DATA

R_{25} (Ω)	$B_{25/85}$-value 1) (K)	P_{max} at T_{amb} = 25 °C (W)	dissipation factor approx. (mW/°C)	thermal time constant approx. (s)	colour code see Marking I	II	III	catalogue number 2)
150	3500	1	10	55	brown	green	brown	2322 643 1.151
470	3750	1	10	55	yellow	violet	brown	1.471
500	4000	1	10	55	brown	green	red	1.152
700	4200	1	10	55	yellow	violet	red	1.472
150	3600	1.5	13	120	brown	green	brown	2322 644 1.151
470	3900	1.5	13	120	yellow	violet	brown	1.471
500	4200	1.5	13	120	brown	green	red	1.152
700	4300	1.5	13	120	yellow	violet	red	1.472

Tolerance on resistance value at 25 °C (R_{25}) — ±20 and ±10% 2)

Tolerance on B-value — ±5%

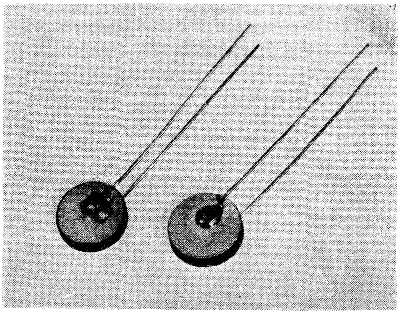
Operating temperature range at zero power — −25 to +125 °C

PACKAGING

Type 2322 643 — 250 pieces per box (cardboard)
Type 2322 644 — 100 pieces per box (cardboard)

1) B-value is subject to change
2) 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
B25/85-value	4650 °K	3350 °K
Maximum current (r.m.s.)	1.7 A	2.2 A
Dissipation factor	19 mW/degC	17 mW/degC
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

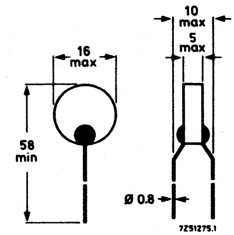
For limiting surge current, e.g. diode and switch protection.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm



Marking

The thermistors are not marked.

Weight

Type 2322 644 90004	approx. 3.2 g
Type 2322 644 90005	approx. 4 g

Mounting

In any position by soldering. Soldering should be done at least 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

ELECTRICAL DATA

	2322 644 90004	2322 644 90005	unit
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

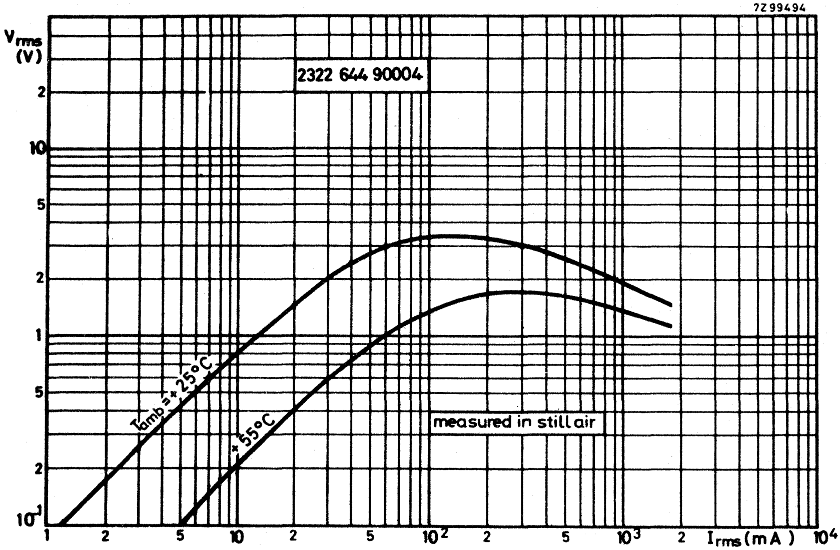


Fig. 3. Typical voltage/current characteristics

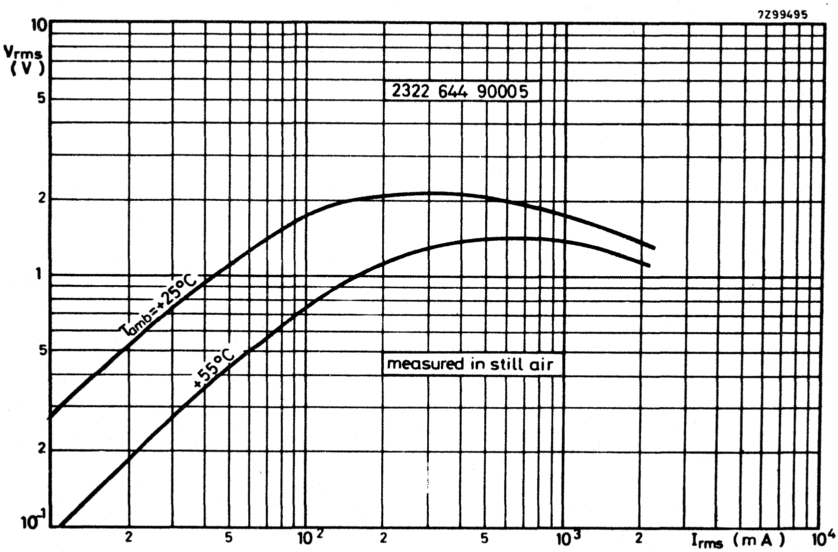


Fig. 4. Typical voltage/current characteristics

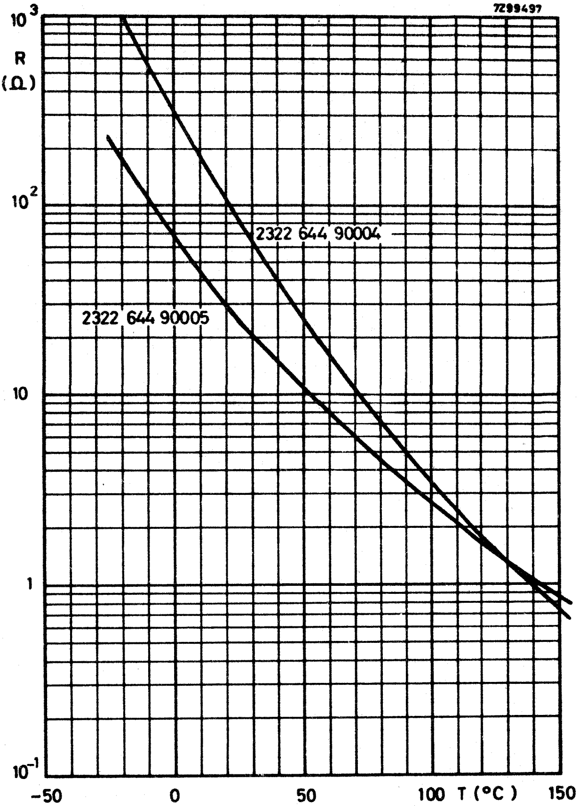


Fig. 5. Typical resistance/temperature characteristics

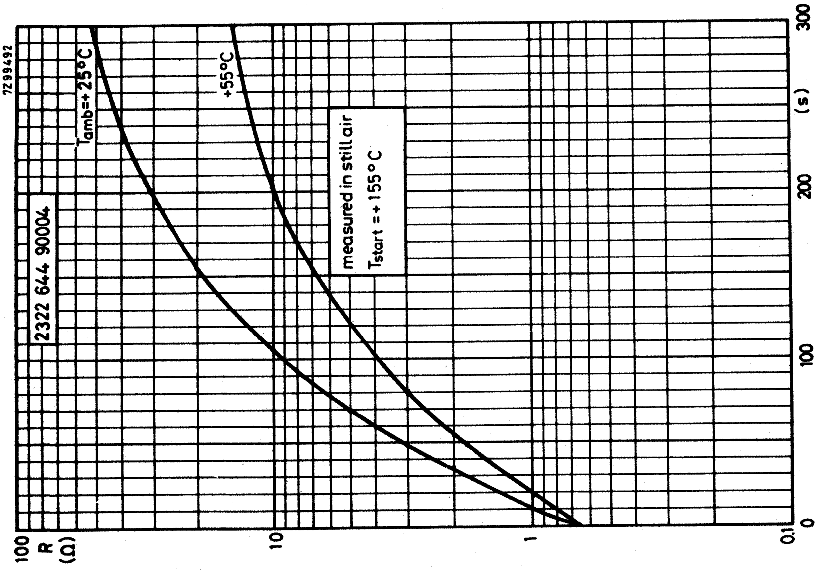


Fig. 6. Typical resistance/time (Cooling) characteristics

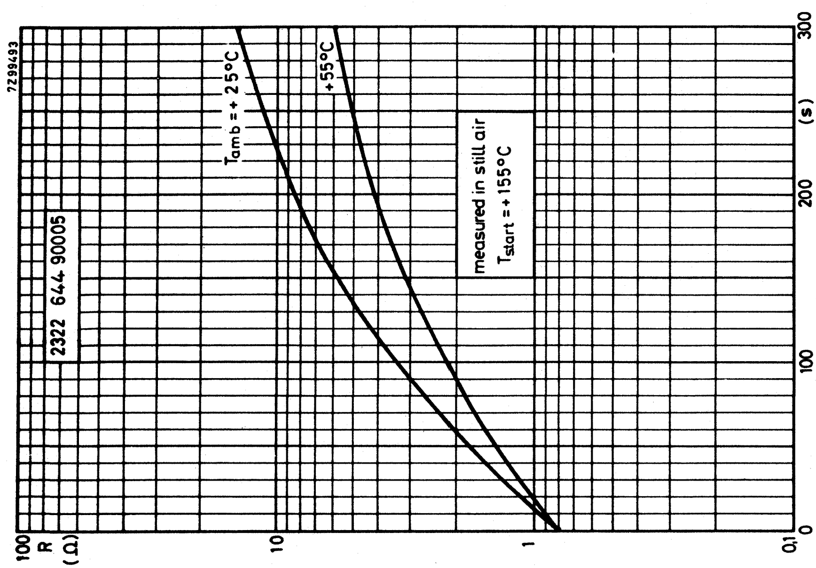


Fig. 7. Typical resistance/time (Cooling) characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔR/R25 (%)
Cold at −25 °C	A	1000 h	± 10
Storage at +25 °C	H	1000 h	± 10
Dry heat at +155 °C	B	1000 h	± 20
Thermal shock −25 to +155 °C	Na	5 cycles	± 20
Damp heat	Ca	1000 h	± 15
Maximum current at Tamb = +25 °C		1000 h	± 20
Cycling [3]			
Quick		250 cycles 5 s on/5 s off	± 20
Slow		2000 cycles 1 min on/9 min off	± 20
Robustness of terminations	U		
Tensile strength 20 N	Ua	10 s	[1]
Bending 10 N	Ub	2 times	[1]
Soldering	T		
Solderability at 230 ± 10 °C	par.3.2.3	3 to 4 s	[2]
Resistance to heat at 230 ± 10 °C	par.3.2.4	3 to 4 s	± 2

[1]) Leads should neither come loose nor break.
[2]) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
[3]) Measured in the circuit shown in Fig.2.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

Cardboard boxes containing 50 items.

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

Dimensions (mm)

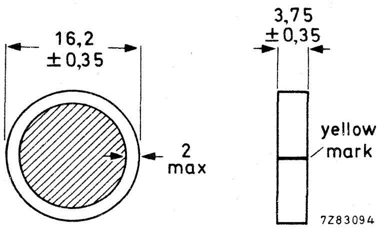


Fig. 1.

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

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

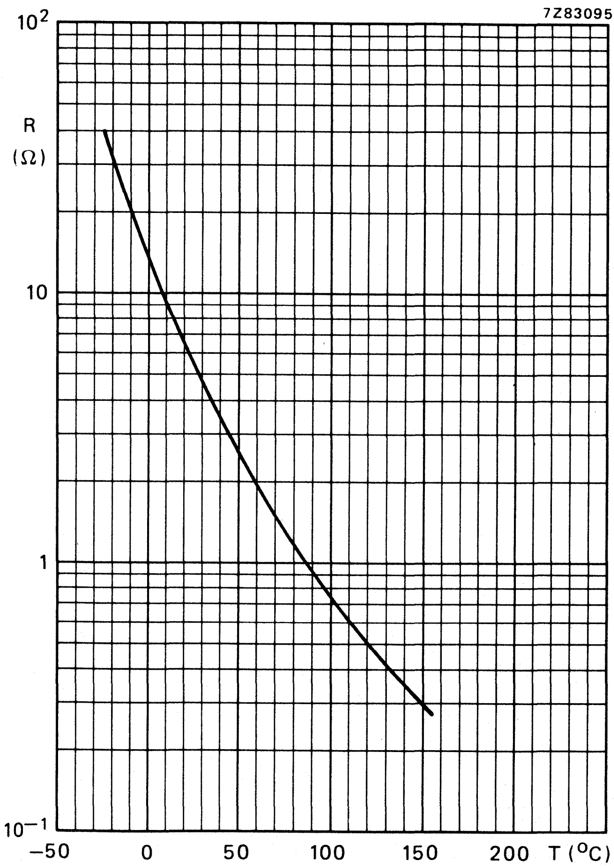


Fig. 2 Typical resistance/temperature characteristic.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical
A.Q.L. 4 %, minor defects – Physical.

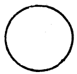
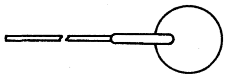
PACKAGING

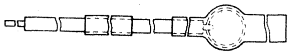
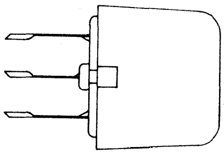
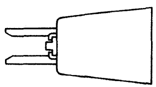
10 preformed sheets of polystyrene containing 75 items in a cardboard box. Resistance value and catalogue number are printed on the box.

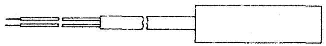
POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC)

	page
Survey	2
Introduction	5
Electrical properties	7
Explanation of terms	14
How to measure PTC thermistors	18
Applications	19
Data sheets	25

SURVEY

	maximum voltage	R_{25} Ω	switch temperature °C	dissipation factor mW/K	temperature coefficient %/K	catalogue number
DISC 	400 V (r.m.s.)	70 to 100	105	11,5	35	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.)	14 to 26	125	21	28	2322 663 93003
	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 189-191
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
PTC/NTC combination	265 V (r.m.s.)	40/130	65 (PTC)	12,5	26 (PTC)	2322 662 98012
DISC for compensation of telephone line variations 	33 V (d.c.)	115 ± 25	97	3,9	10	2322 672 98001

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 240	200	17 ± 20%	max. 7	120 V	2322 680 90058
	100 to 240	200	17 ± 20%	max. 7	120 V	2322 680 90061
	100 to 240	200	15 ± 20%	max. 7	120 V	2322 680 90134
double insulated	100 to 240	500	15 ± 20%	max. 7	220 V	2322 680 90047
double insulated	100 to 265	500	17 ± 20%	max. 8	220 V	2322 680 90011
double insulated	100 to 265	200	17 ± 20%	max. 7	120 V	2322 680 90059

INTRODUCTION

P(ositive) T(emperature) C(oefficient) thermistors are resistors with a high positive temperature coefficient of resistance. In several aspects they differ from NTC thermistors described in this booklet:

(1) The temperature coefficient of a PTC thermistor is positive only between certain temperatures, outside these temperatures the temperature coefficient is zero or negative.

(2) The absolute value of the temperature coefficient of PTC thermistors is in most cases much higher than that of NTC thermistors.

PTC thermistors are applied as excess current limiters, temperature sensors and protection devices against overheating in all kind of apparatus such as electric motors, washing machines, alarm installations etc. They are also used as level indicators, time delay devices, thermostats, compensation resistors etc.

PTC thermistors are prepared from $BaTiO_3$, or solid solutions of $BaTiO_3$ and $SrTiO_3$ in a way which is analogous to the method for preparing NTC thermistors. A certain amount of 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 or Bi for Ba or substitution of pentavalent ions like Sb^{5+} or Nb^{5+} for Ti. Both methods lead to identical results. If carefully prepared, in the absence of oxygen, these semiconductors have a normal, weakly negative temperature coefficient. The interesting PTC effect is obtained by firing the ceramic samples in the presence of oxygen. It is caused by the penetration of oxygen from the atmosphere along pores and crystal boundaries during the cooling part of the firing process. The oxygen atoms, adsorbed 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.

$$R_b \propto \frac{1}{a} \, e^{eV_b/kT}$$

Here a represents the size of the crystallites, thus $\frac{1}{a}$ the number of barriers per unit length of the thermistor. V_b represents the electrical potential of the barriers. As V_b is inversily 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 ferro-electric nature like $BaTiO_3$ and its solid solutions. Above their ferro-electric Curie temperature Θ the relative dielectric constant decreases with temperature according to

$$\varepsilon_r = \frac{C}{T - \Theta}$$

where C has a value of roughly 10^5 K. As a result the resistivity increases sleepily 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, above 160 to 200 °C, the electrons captured at the boundaries are gradually liberated. As a result the potential barriers decrease in strength, so that the PTC temperature region is followed by an NTC region. 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 R_b, or better of the extra impedance Z_b. Above 1 to 5 MHz Z_b has completely disappeared. The characteristic properties described in the following paragraphs are thus restricted to low frequencies.

MANUFACTURING PROCESS

The manufacturing process can be compared with that of NTC thermistors. Mixtures of barium carbonate, strontium and titanium oxides and other materials depending on the required electrical characteristics are milled, mixed and pressed into a suitable form. After drying, the PTC's are sintered at a very high temperature. After the contacts have been applied with the utmost care on this n-type semiconductor, leads can be soldered on the contact surfaces. Most PTC types with leads are further protected by a special lacquer.

$\propto$ = directly proportional with

ELECTRICAL PROPERTIES

RESISTANCE VERSUS TEMPERATURE CHARACTERISTICS

The relation between resistance value and temperature is difficult to express in a compact formula (as was done for NTC). Being not simply the reverse of an NTC curve, the PTC characteristic is more complicated. In Fig.1 a comparison is given of the general behaviour of NTC and PTC thermistors. Generally speak-

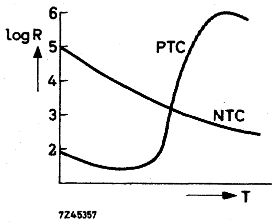


Fig.1.
Resistance/temperature characteristics of an NTC and PTC thermistor.

ing, PTC thermistors have at the lower end of the temperature scale a zero or negative temperature coefficient of resistance. Going to higher temperatures the temperature coefficient of resistance changes to a high positive value up to a temperature of approximately 150 °C. Above that temperature the temperature coefficient decreases and becomes negative.

In some cases the resistance/temperature relation can be expressed by the formula:

$$R_T = A + Ce^{BT}, \quad \text{for } T_1 < T < T_2$$

in which R_T = resistance at the temperature T of the PTC

T = temperature of the PTC

A, C and B constants

T_1 = minimum temperature for which the formula applies.

T_2 = maximum temperature for which the formula applies.

From this formula we find after differention the temperature coefficient:

$$\alpha = \frac{1}{R} \cdot \frac{dR}{dT} = \frac{BC\, e^{BT}}{A + Ce^{BT}}$$

which yields to

$$\alpha = 100B \,\%\text{ per deg C}$$

for that part of the characteristic where $R_T \gg A$.

However, in practice it seldom occurs that the R/T characteristic can be described by the above or another simple formula, so calculations have to be based on graphical methods. As a practical indication of the temperature at which the PTC thermistor starts to have a usable temperature coefficient, the switch temperature T_{switch} has been introduced, being defined as the higher of the two temperatures at which the value of the resistance of the PTC is twice that of the minimum resistance [1]).

VOLTAGE VERSUS CURRENT CHARACTERISTICS

The static voltage/current characteristics are very interesting as these curves clearly show the current limiting ability of the PTC thermistors. Up to a certain voltage the V/I characteristic is a straight line following ohm's law but as soon as the PTC is heated up by the current so much that its temperature reaches the switch temperature, the resistance value increases (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 (Fig.3). PTC thermistors show a certain degree of voltage dependency. At higher voltages the resistance value is somewhat lower than expected. This is the reason why a V/I characteristic is difficult to calculate from the R/T curve with the given dissipation constant. (see: Electrical properties of NTC thermistors, page C7).
It is, however, possible to calculate the top of the V/I characteristic with very good approximation if the R/T characteristic and the dissipation constant is known.

The calculation goes as follows:

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

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

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

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

Also $\Delta W = D \Delta T$ thus:

$$\Delta W_p = D \Delta T_p = I_p^2 \Delta R_p$$

or

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

[1]) The curie temperature, wellknown as an indication for the behaviour of ceramic capacitors and magnetic materials, is less suitable for use as a practical measure for PTC thermistors.

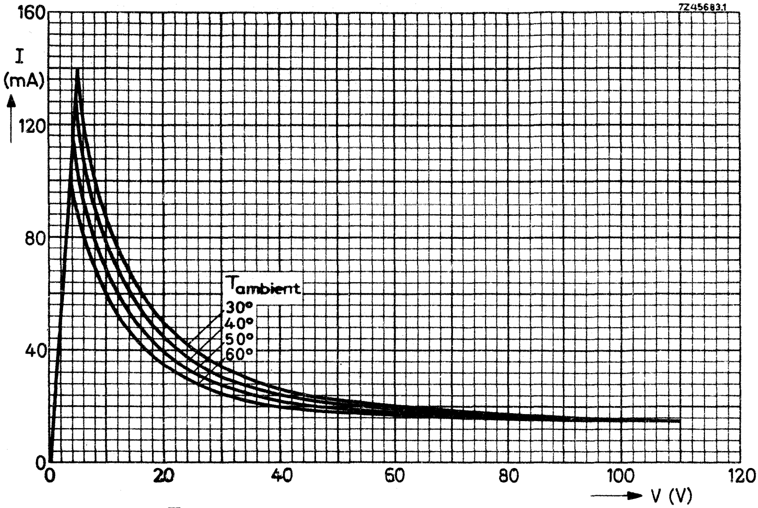


Fig.2.
Voltage/current characteristics of a PTC thermistor at different ambient temperatures on a linear scale.

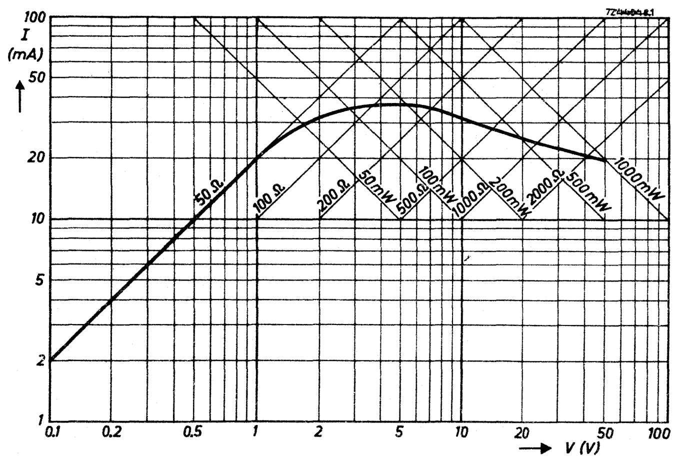


Fig.3.
Voltage/current characteristic on a logarithmic scale.

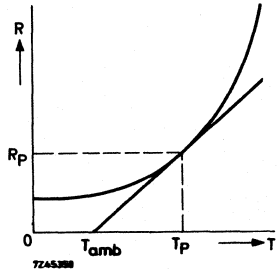


Fig.4.
Part of the resistance/temperature characteristic on a linear scale.

In Fig.4, the R/T characteristic on linear scale, we see:

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

so

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

With given ambient temperature (T_{amb}) and D, the values 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.
Furthermore it can be seen that R_p and T_p are independent of the surrounding medium.

PTC THERMISTOR IN SERIES WITH A LOAD

With the voltage/current characteristic it can be shown that due to the non-linearity of the PTC-curve three working points are possible when a load R is connected in series with the PTC (Fig.5). The characteristic of the load is a straight line intersecting the voltage 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:

(1) V_a increases (Fig.6);

(2) the ambient temperature increases (Fig.7);

(3) the load resistance decreases (Fig.8).

The PTC is thus an excellent protective device as it limits the current through the load to a safe value if supply voltage, temperature or current surpass a critical value.

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

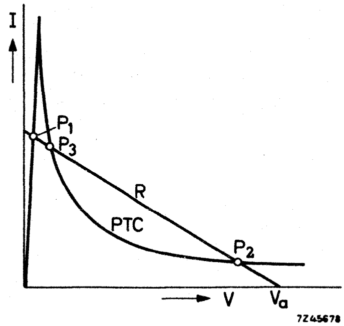


Fig.6.
PTC thermistor in series with a load showing the influence of the supply voltage V_a.

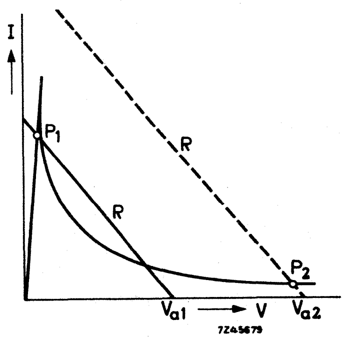


Fig.7.
PTC thermistor in series with a load showing the influence of the ambient temperature.

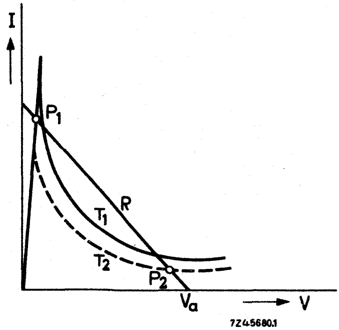
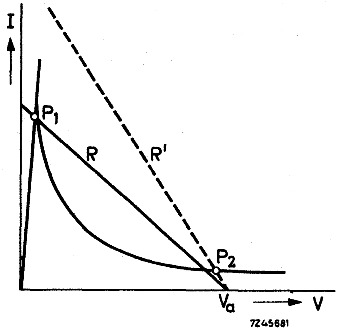


Fig.8.
PTC thermistor in series with a load showing the influence of the load resistance.



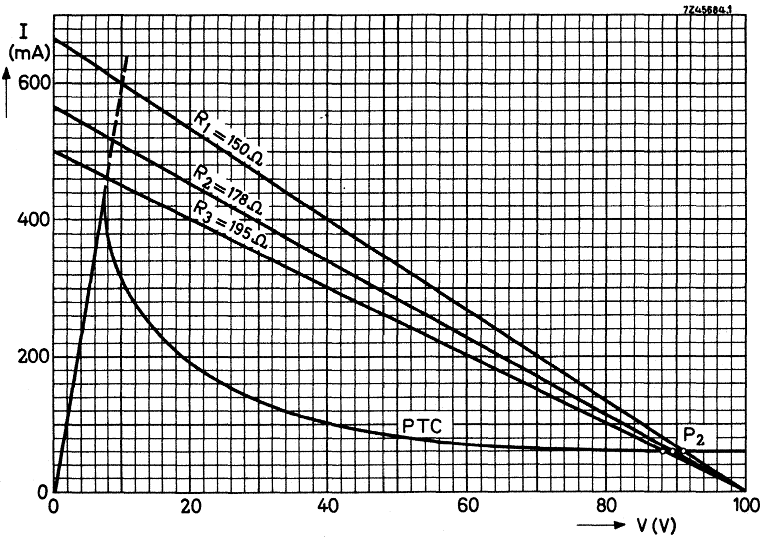


Fig. 9. PTC thermistors in series with different resistors.

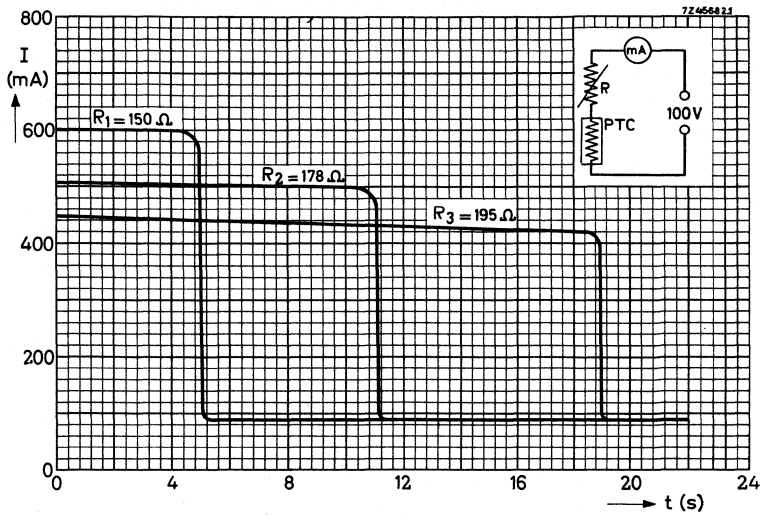


Fig.10. Current/time characteristics showing the influence of the value of the load.

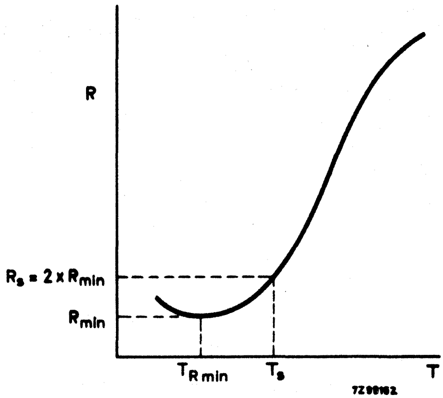
CURRENT/TIME CHARACTERISTICS

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.

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. 1).
So, at $T_s > T_{Rmin}$: $R_s = 2\ R_{min}$

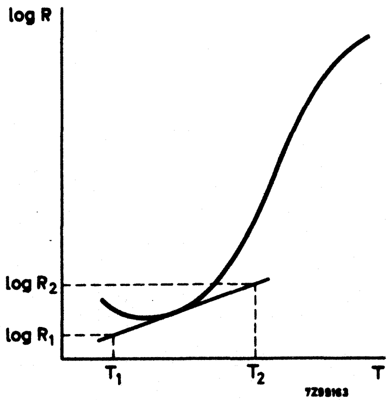


Temperature coefficient (α)

The temperature coefficient $\alpha = \frac{1}{R}\ \frac{dR}{dT}$.
For R-T curves plotted on a log R-lin T scale, as they practically all are, we can work out

$$\alpha = \frac{d\ \ln R}{dT} = \frac{1}{0.4343} \cdot \frac{d\ \log R}{dT}$$

It can be seen that the tangent at a point of the R-T characteristic (see Fig.2) is proportional to the α at that point.

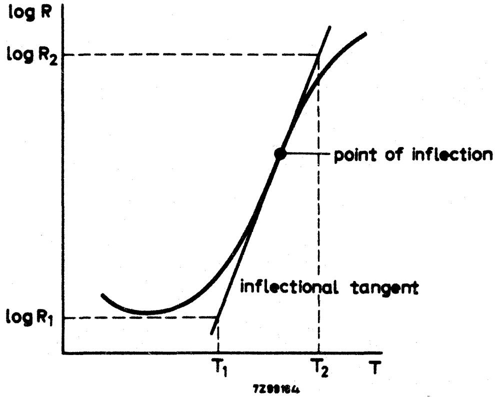


α can be calculated from

$$\alpha = \frac{100}{0.4343} \cdot \frac{\log R_2 - \log R_1}{T_2 - T_1} \ \%/\text{deg C}$$

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

In the data sheets the maximum temperature coefficient is given, this is the α measured at the inflection point of the log R-lin T characteristic (i.e. the point where $\frac{d^2 \log R}{d\,T^2} = 0$, see Fig.3)



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

$$\alpha = \frac{100}{0.4343} \cdot \frac{1}{T_2 - T_1} \ \%/\text{deg C}$$

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 $T_s > 25\,^{\circ}C$):

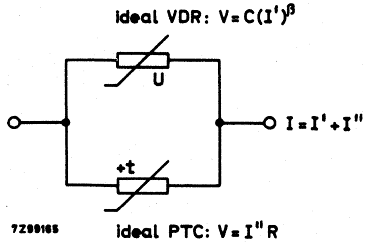
Measure T_1, being the temperature of the PTC at V_{max}, at an ambient temperature of $T_o = 25\,^{\circ}C$; T_s is known, then τ can be calculated from:

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

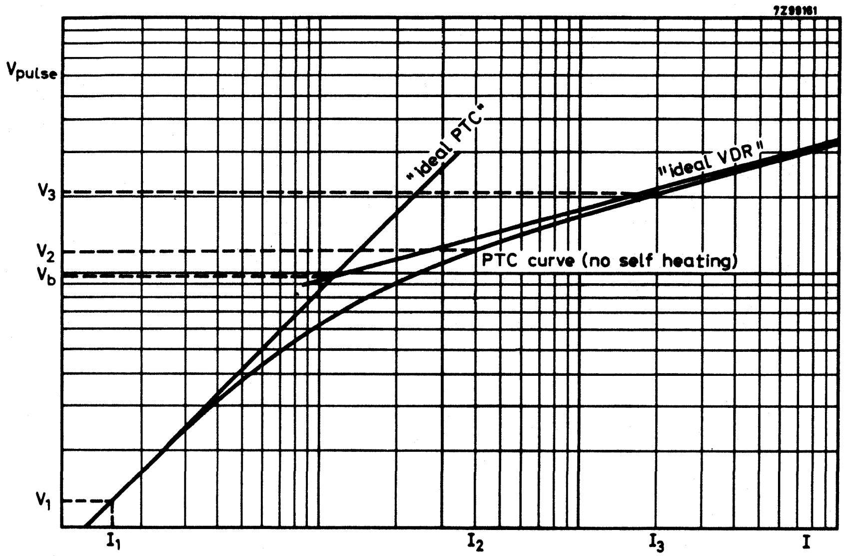
where t is the time required for cooling the PTC from T_1 to T_s in still air of 25 °C.

Voltage dependence aspects

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" following exactly the formula $V = C.I^{\beta}$ (see Fig.4).



Plotted on a log I-log V scale at an arbitrary constant temperature the ideal PTC and ideal VDR can be represented by 2 straight lines (see Fig.5).



These lines can be seen to 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 important.

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-value of the ideal VDR, being a measure for the voltage dependence of the

the PTC, can be calculated with the formula:

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

with V_3 and V_2 being pulse voltages > V_b and $R = \frac{V_1}{I_1}$, measured at $V_1 \leq 1.5\ V_{dc}$.
The β-value is also specified at a certain temperature.

V_b and β-value are useful parameters for estimating the voltage dependence of a particular PTC.

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 °C 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 °C may result if it is not used. (See "Handbook of Chemistry and Physics", for example.)

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 degrees above the surface of the substance whose temperature is being determined;
F = correction factor.

For approximate work, and when a mercury thermometer is employed, a value for F of 0,00016 is generally used.

For example with T_o = 110 °C, T_m = 70 °C and L = 50 °C we find: T_c = 110,32 °C, thus without stem correction an error of more than 0,3 °C 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 resistance values of standard PTC thermistors are specified at the following temperatures:

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

The switch temperature is also given.

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

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 wider. 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:

(1) Applications where the temperature of the PTC is primary determined by the temperature of the ambient medium.

(2) 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 limiting of current relay retardation, fluid-level indication and circuits for protection against over-voltages and short circuits.
Principle circuits of the above mentioned applications are given in the following pages.

No details of component data are mentioned as these can be calculated on basis of available supply voltages and data of relays or other vital components. Details on more complicated circuits will be given on request.

REMARKS ON THE USE OF PTC THERMISTORS

Do not apply a voltage above V_{max} to the PTC, since this may result in a breakdown of the thermistor.

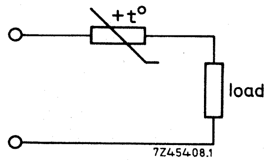
Do not connect PTC thermistors in series in order to obtain higher permissible voltages or wattages: this may lead to a breakdown of the PTC which heats up a bit faster than the other(s) which results in too high voltage over this particular PTC.

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

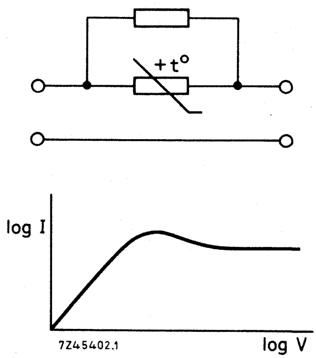
Protection against over-voltage and short-circuit

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



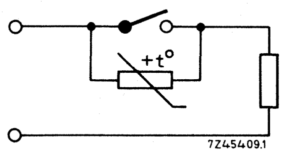
Current stabilization

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



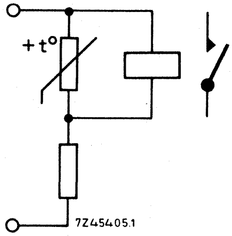
Spark suppression

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



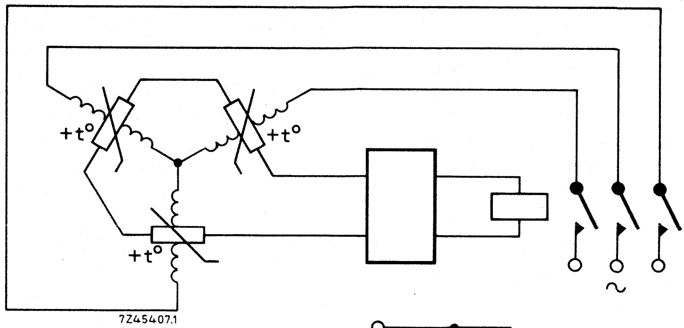
Delaying action relays

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



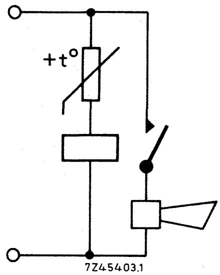
Temperature protection of electric motors

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



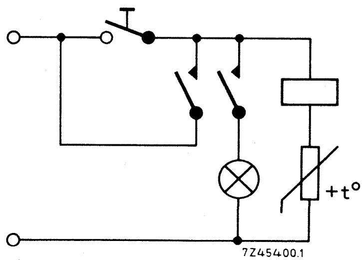
Alarm installation

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



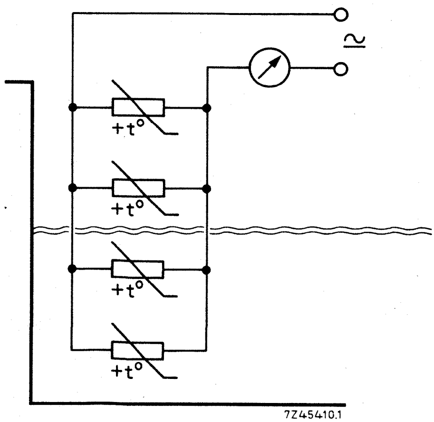
Time delay circuit

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 value of the PTC.



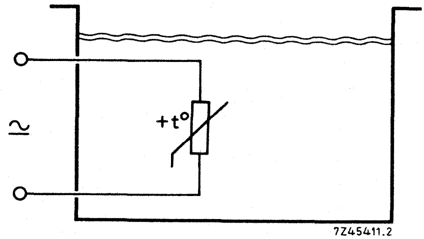
Liquid-level indication

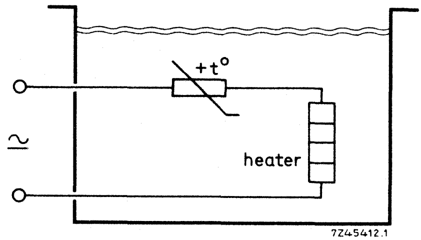
The PTC thermistors above the fluid-level will be heated to a temperature above T_{switch}. When immersed they are cooled so that their resistance value is low.



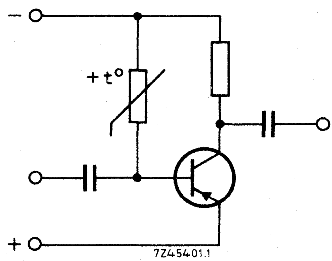
Thermostatically controlled heating circuits

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.



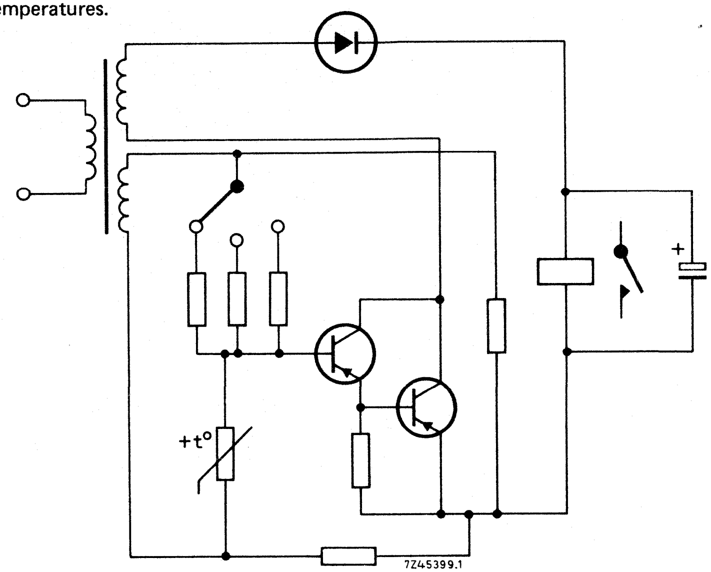


Temperature compensation of transistor circuits



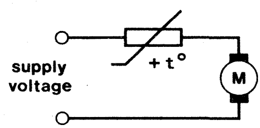
Thermostat for washing machines

A thermostat for three temperatures.



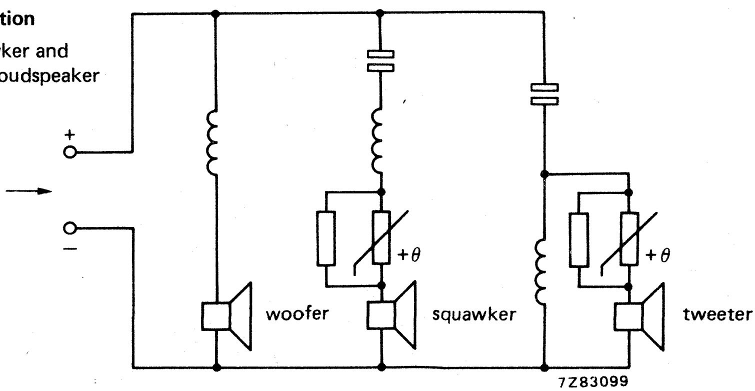
Protection of electric motors against overheating due to blocking

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

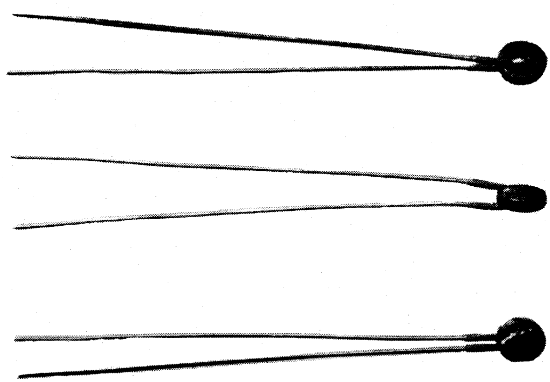
Protection of squawker and tweeter in a 3-way loudspeaker system.



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%/°C approx.
Max voltage at T_{amb} = +55 °C	25 V d.c.
Dissipation factor	6 mW/°C approx.
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +55 °C



RZ 28448-1

APPLICATION

Temperature compensating and temperature measurement purposes.

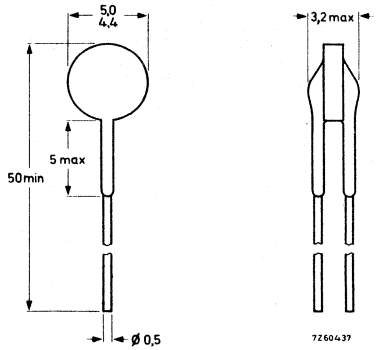
DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Outlines



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% 1)
	at + 80 °C	3700 Ω ± 30% 1)
Switch temperature		+6 °C approx.
Temperature coefficient		+5%/°C approx.
Dissipation factor		6 mW/°C approx. 2)
Heat capacity		0, 1 J/°C approx. 2)
Thermal time constant		17 s approx. 2)
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

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

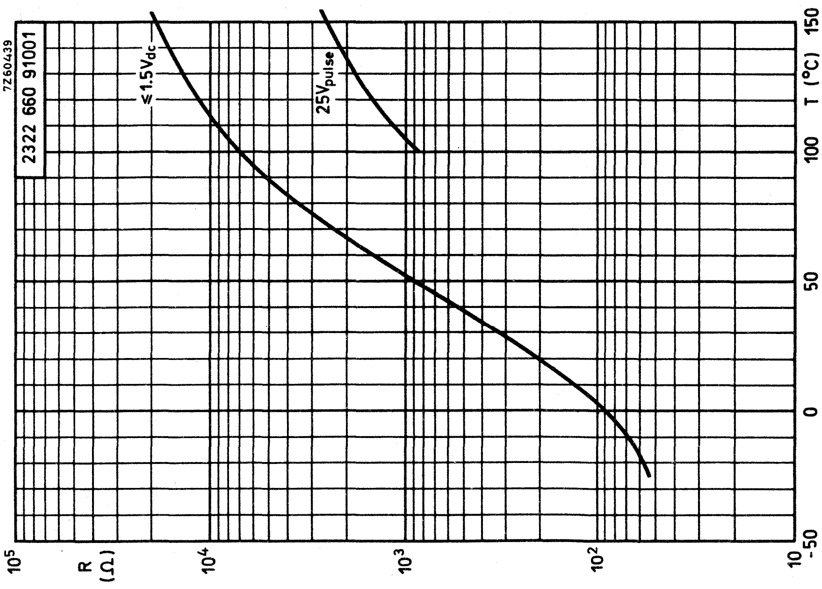


Fig. 2 Typical resistance/temperature characteristics

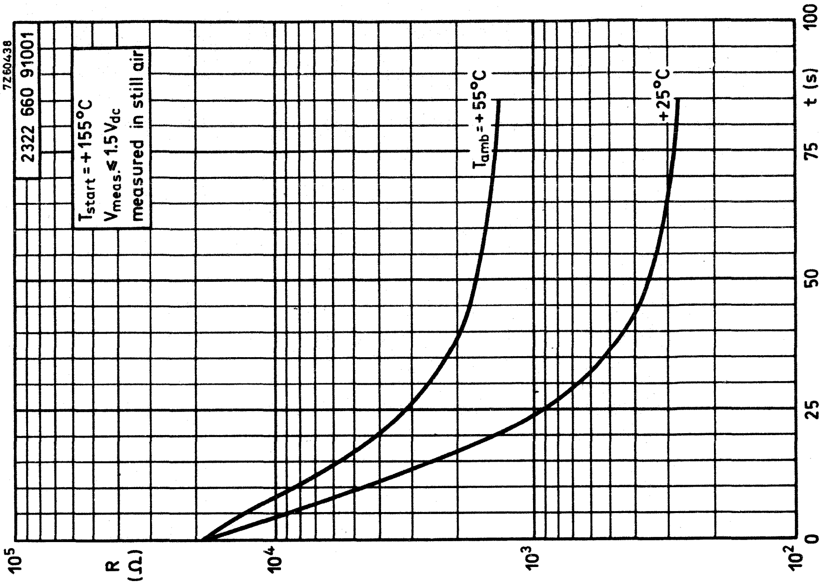


Fig. 3 Typical resistance/time (cooling) characteristics

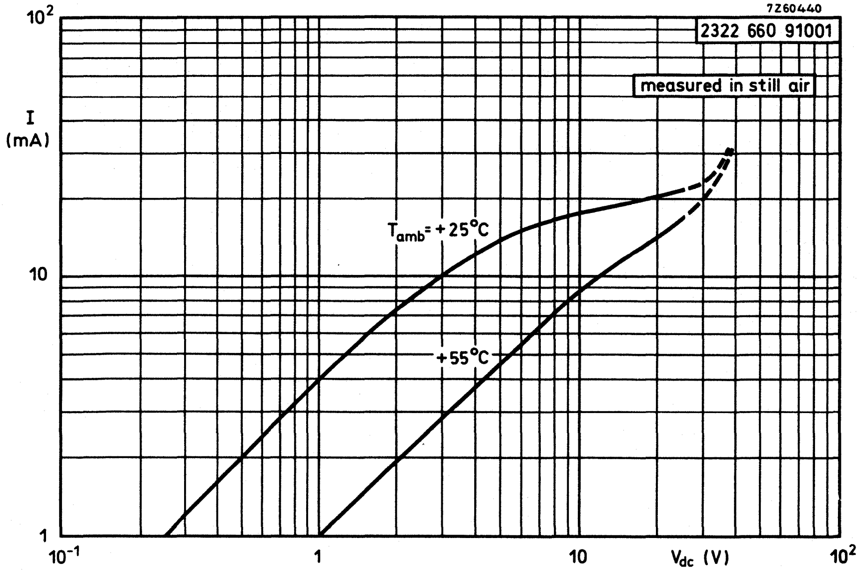


Fig. 4 Typical current/voltage characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +80 °C
Cold at −25 °C	A	1000 h	± 3	± 5
Storage at +25 °C	H	1000 h	± 3	± 5
Dry heat, + 155 °C	B	1000 h	± 5	± 10
Thermal shock −25 to + 155 °C	Na	5 cycles	± 3	± 7
Damp heat	Ca	1000 h	± 5	± 7,5
Dissipation at V = 25 V d.c. and T_{amb} = +55 °C		1000 h	± 5	± 10
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	[1]	
Bending 2,5 N	Ub	2 times	[1]	
Soldering	T			
Solderability at 230 ± 10 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 260 ± 5 °C	T_b	10 to 11 s	± 2	± 2

[1]) Leads should neither come loose nor break.
[2]) Leads must be solderable, initially and after six months storage, with solder containing resin flux.

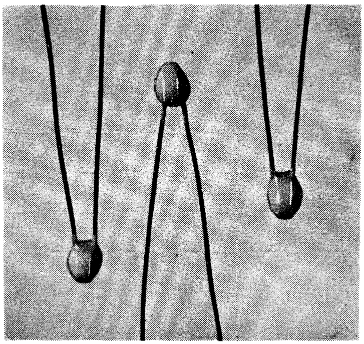
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

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	25 V d.c.
Dissipation factor	7 mW/°C approx.
Operating temperature range at zero power at V_{max}	 −10 to + 125 °C [1] 0 to + 55 °C



RZ 19269

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

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

[1]) PTC thermistor 2322 660 91009: −10 to + 150 °C.

MECHANICAL DATA

Dimensions in mm

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

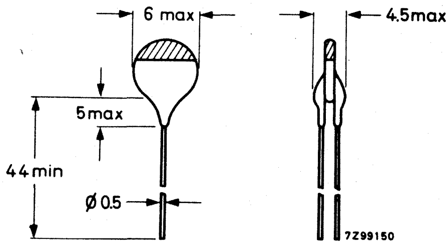


Fig. 1.

Marking

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

Weight 0.4 g approximately

Mounting In any position by soldering

ELECTRICAL DATA

	catalogue number 2322 660 followed by 91006	91007	91008	91009	unit
Resistance at 25 °C 1)	60	50	50	50	Ω
Resistance at 125 °C 1)	3 to 15	100 to 500	50 to 500		kΩ
Resistance at 150 °C 1)				0.1 to 1.2	MΩ
Switch temperature	30	50	80	105	°C
Temperature coefficient	7	16	23	40	%/deg.C
Heat capacity 2)	0.13	0.13	0.13		J/deg C
Thermal time constant 2)	20	18	18		s
Voltage dependence β	0.19	0.17	0.18		
Balance voltage	35	12.5	23		V_{dc}

Tolerance on R_{25} ± 30%
Max. voltage 25 Vd.c.
Dissipation factor 7 mW/degC approx.
Operating temperature range
at zero power −10 to +125 °C 3)
at V_{max} 0 to +55 °C

1) Measuring voltage not exceeding 1.5 V_{dc} to avoid internal heating.
2) Measurements made with specimen in phosphor bronze clips, in still air.
3) [illegible]

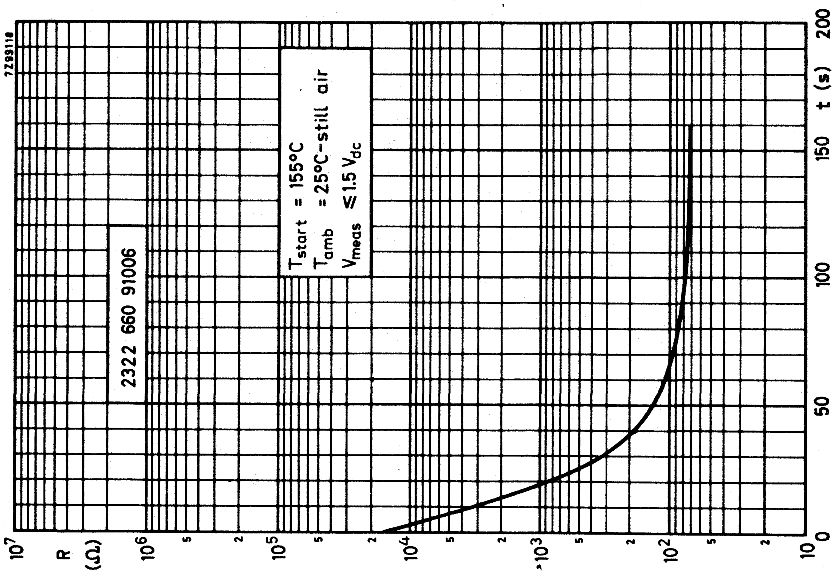


Fig.3.
Typical resistance/time (cooling) characteristic

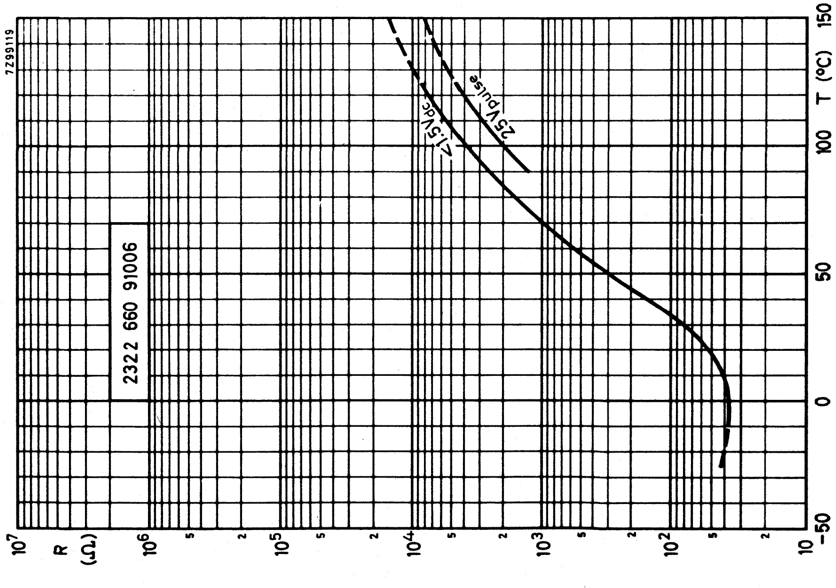


Fig.2.
Typical resistance/temperature characteristics

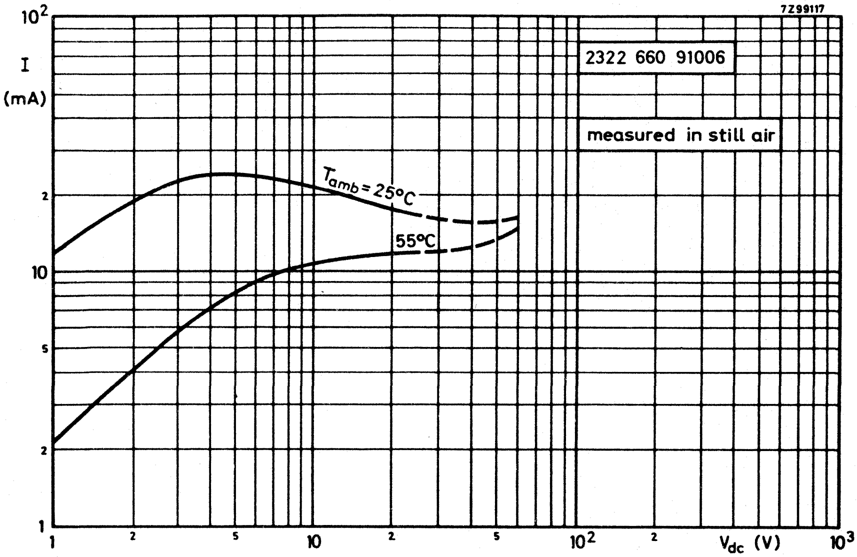


Fig.4. Typical voltage/current characteristics

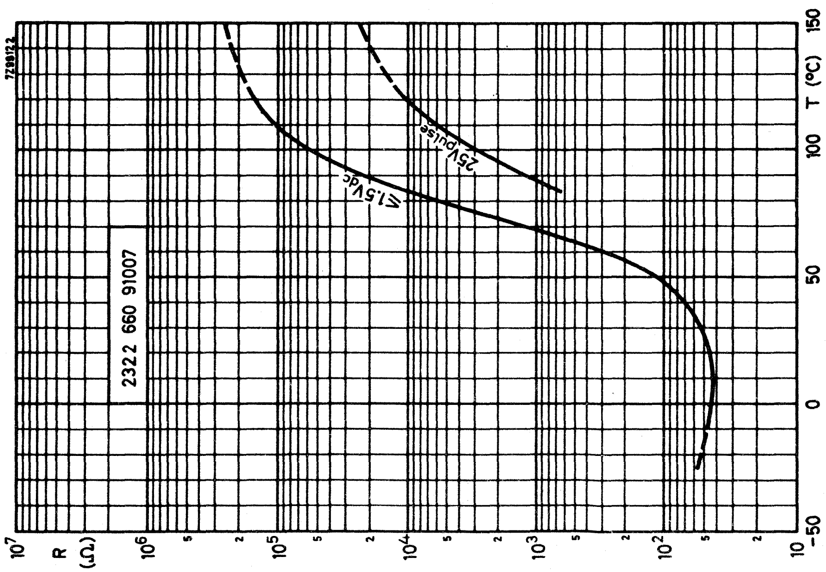


Fig. 5.
Typical resistance/temperature characteristics

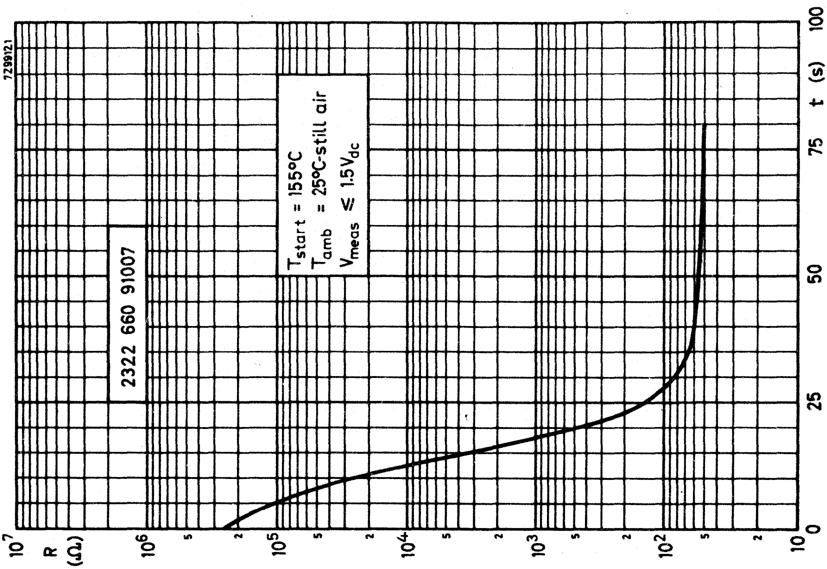


Fig. 6.
Typical resistance/time (cooling) characteristic

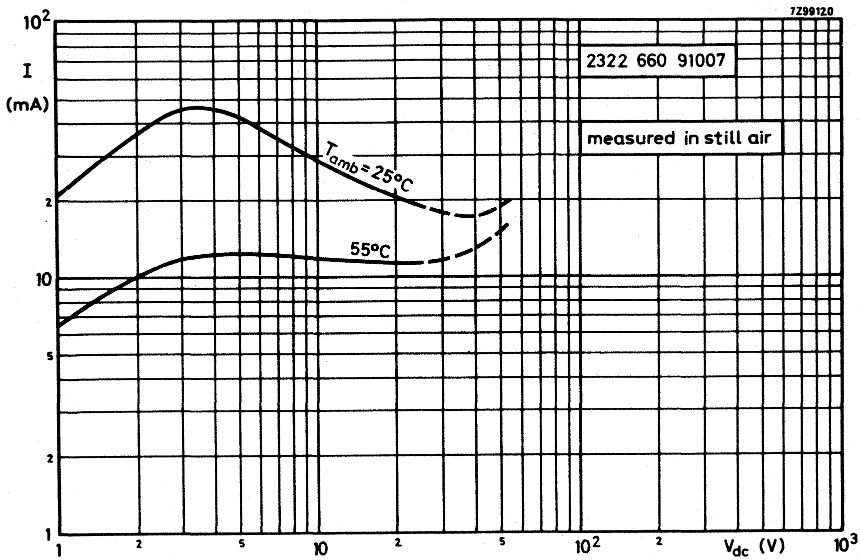


Fig. 7. Typical voltage/current characteristics

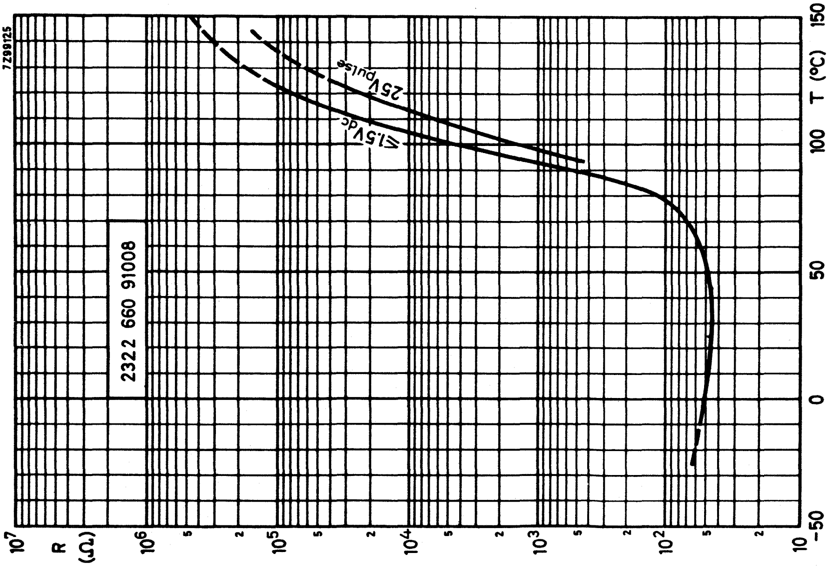


Fig. 8.
Typical resistance/temperature characteristics

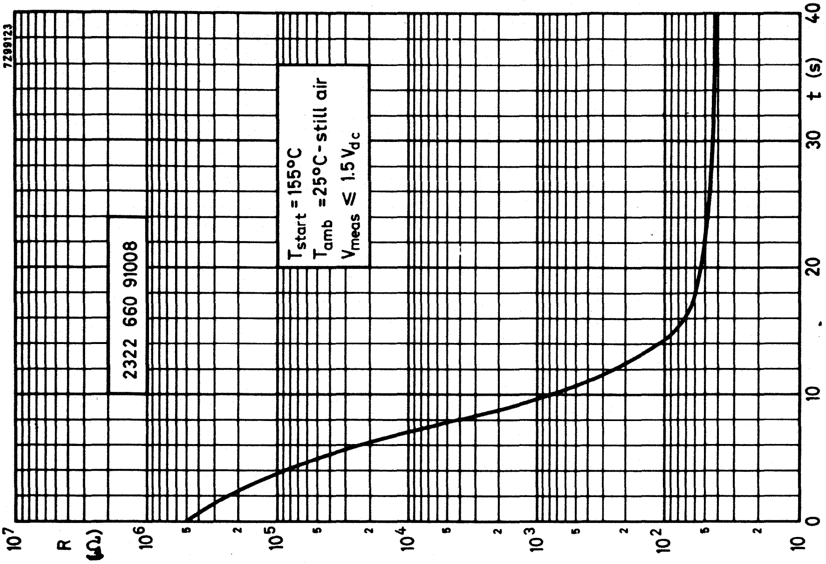


Fig. 9.
Typical resistance/time (cooling) characteristic

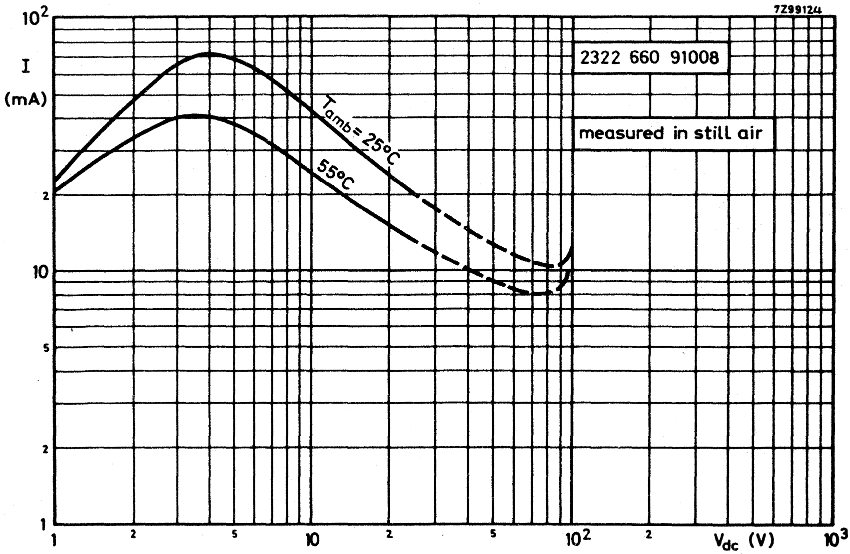


Fig. 10. Typical voltage/current characteristics

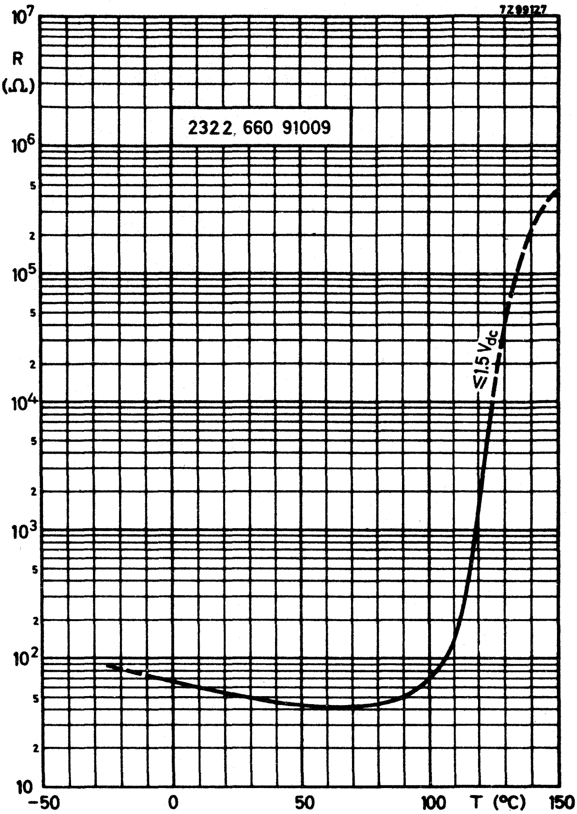


Fig. 11. Typical resistance/temperature characteristic

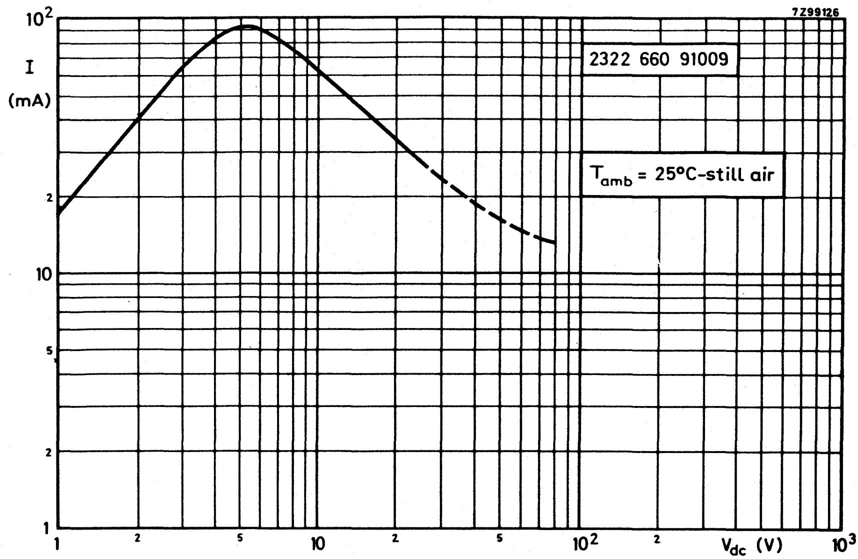


Fig. 12. Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to I.E.C.68, unless otherwise specified.

test	test method	duration	ΔR/R in % at 25 °C	at 125 °C
Cold at −10 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat + 125 °C	B	1000 h	± 5	± 5
Thermal shock −10 to + 125 °C	Na	5 cycles	± 3	± 3
Damp heat	C	1000 h	± 5	± 5
Dissipation at V = 25 V_{rms} and T_{amb} = +55 °C		1000 h	± 5	± 5
Cycle test at V= 25V r.m.s. and T_{amb} = 0 °C		1000 cycles 1 min on/ 9 min off	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

250 pieces per box (cardboard)

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 %/°C
Maximum r.m.s. voltage	245 V
Dissipation factor	7 mW/°C
Operating temperature range at zero power at maximum voltage	 −25 to + 155 °C 0 to + 55 °C

APPLICATION

Suitable for all kinds of applications, e.g. stair-well lighting control.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

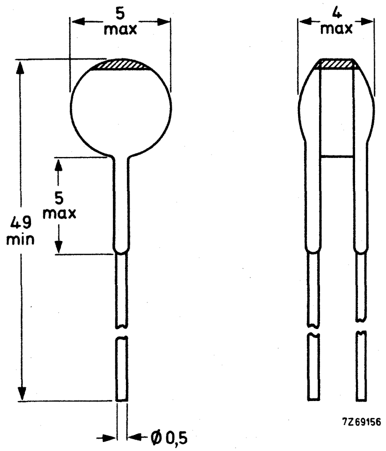


Fig. 1

Marking	Brown band on top
Weight	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 1)	min. 70 000 Ω
Switch temperature	+ 115 °C
Temperature coefficient	+28 %/°C
Dissipation factor	7 mW/°C
Heat capacity	0,125 J/°C
of ceramic only	0,08 J/°C
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 r.m.s. voltage	245 V

1) Measurement made without internal heating occurring.

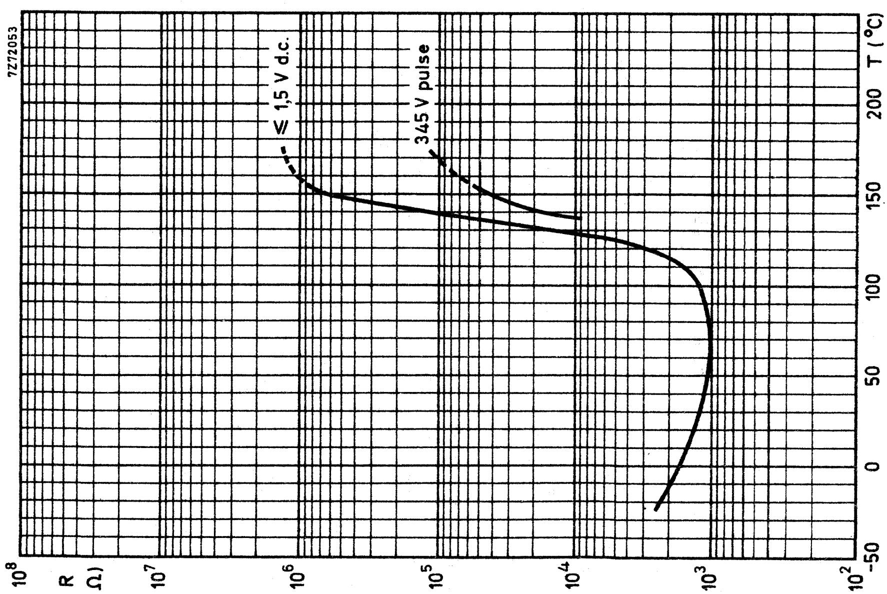


Fig. 2 Typical resistance/temperature characteristics

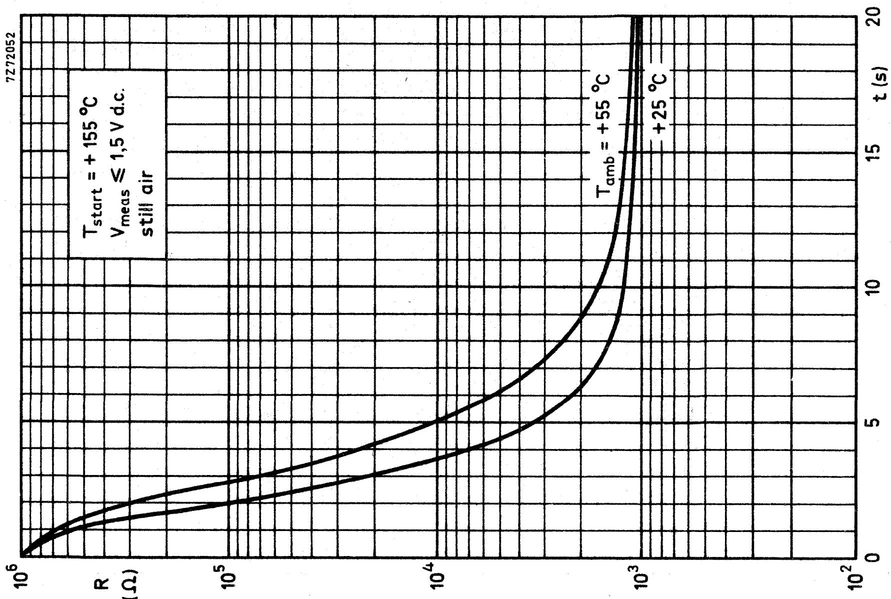


Fig. 3 Typical resistance/time (cooling) characteristics

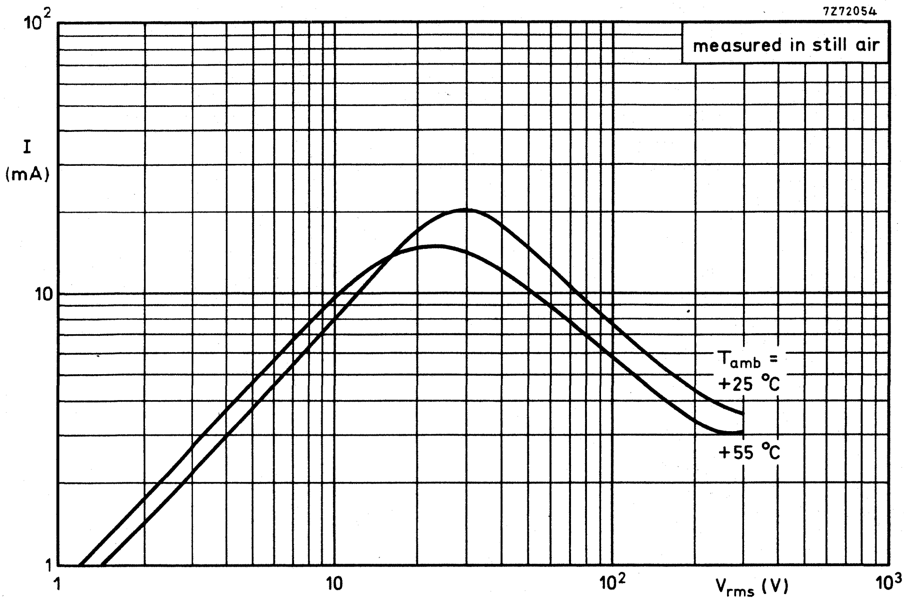


Fig. 4 Typical voltage/current characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +155 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at + 155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to + 155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at + 40 °C	C	1000 h	± 10	± 12
Dissipation at 245 V r.m.s. and T_{amb} = + 55 °C		1000 h	± 10	± 12
Cycle test at 245 V r.m.s.				
T_{amb} = 0 °C		100 cycles 3)	± 10	± 12
T_{amb} = +25 °C		2000 cycles 3)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 5 N	Ua	10 s	1)	
Bending 2,5 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	4)	

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L.	1 %	major defects – Electrical
A.Q.L.	1,5%	major defects – Mechanical
A.Q.L.	4 %	minor defects – Physical

PACKAGING

250 pieces per box (card board).

PTC THERMISTORS
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	30 to 50 Ω
Resistance value at other temperatures	see Table 2
Switch temperature	see Table 2
Temperature coefficient	see Table 2
Max. voltage	see Table 2
Dissipation factor	see Table 2
Operating temperature range	
at zero power	−10 to +125 °C
at V_{max}	0 to +55 °C

APPLICATION

Suitable for all kinds of applications.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

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

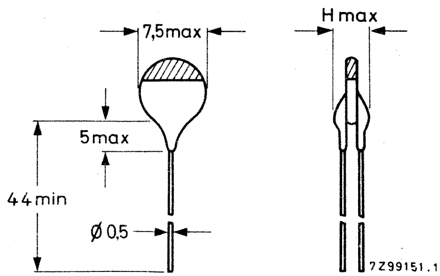


Fig. 1.

Marking

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

Weight 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

ELECTRICAL DATA

Table 2 [1]

R_{25} [2] (Ω)	R at other temperatures [3] T (°C)	R (Ω)	switch temperature (°C)	temperature coefficient (%/deg C)	V_{max} (Vd.c.)	dissipation factor [4] (mW/deg C)	thermal time constant [4] (s)	heat capacity [4] (J/deg C)	voltage dependence β	balance voltage (V)	catalogue number
50	60 100	< 100 > 1 000	+ 80	18	50	8.5	50	0.425	0.48	110	2322 661 91002
40	95 130	< 80 > 10 000	+110	75	50	8.5	50	0.425	0.28	25	2322 661 91003
30	40 100	< 90 > 10 000	+ 45	16	50	8.5	50	0.425	0.25	65	2322 661 91004
50	100	3 000 - 20 000	+ 25	9	40	6	40	0.240	0.35	25	2322 661 91005

Tolerance on resistance at 25 °C (R_{25}) ± 15 Ω

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

1) Typical values, except R and V_{max}.
2) Measuring voltage not exceeding 1.5 V_{dc} to avoid internal heating.
3) Measurements made without internal heating occurring.
4) Measurements made with specimen in phosphor-bronze clips, in still air.

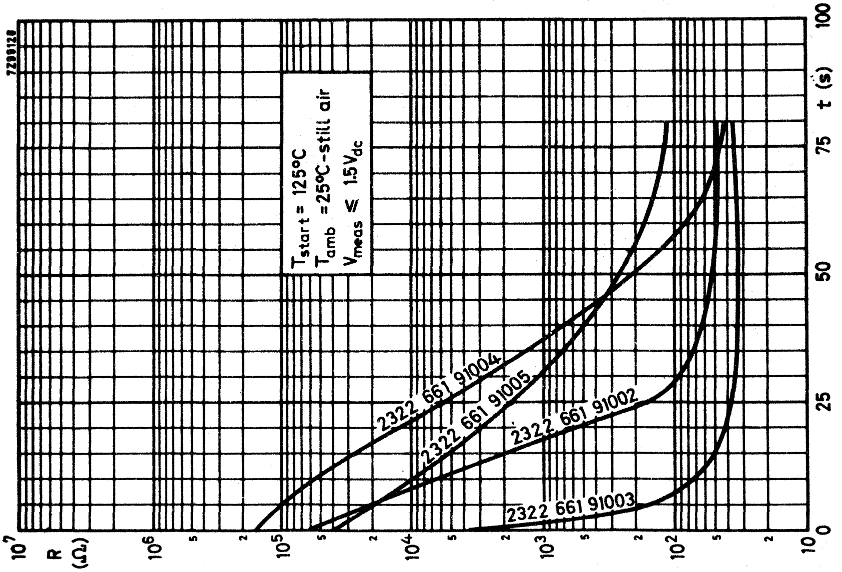


Fig.3. Typical resistance/time (cooling) characteristics

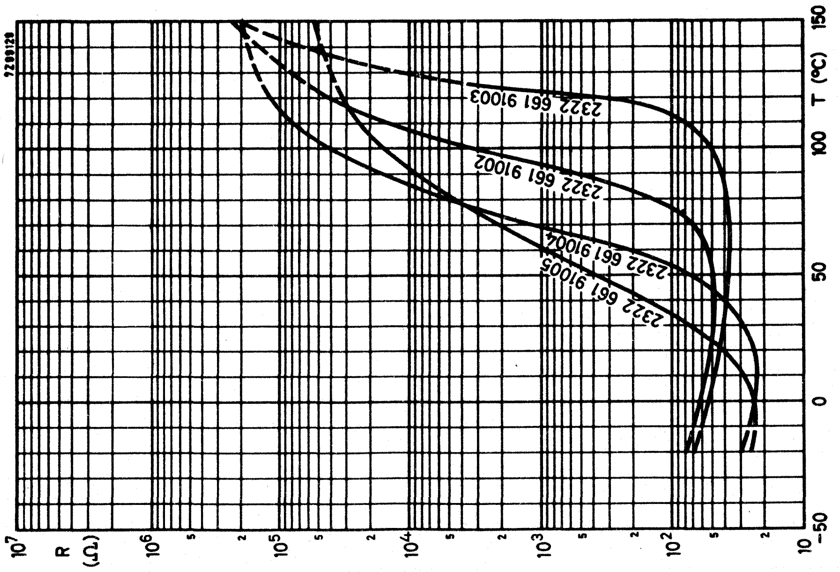


Fig.2. Typical resistance/temperature characteristics

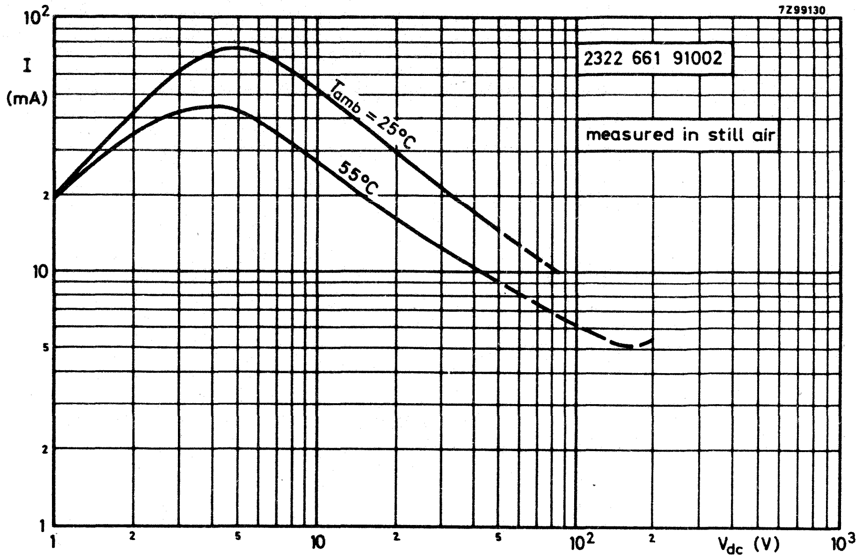


Fig.4a. Voltage/current characteristics

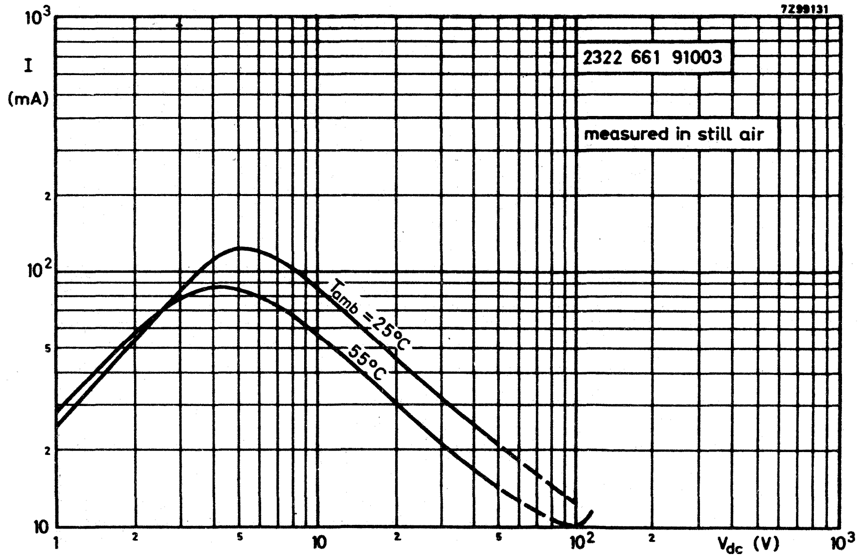


Fig.4b. Voltage/current characteristics

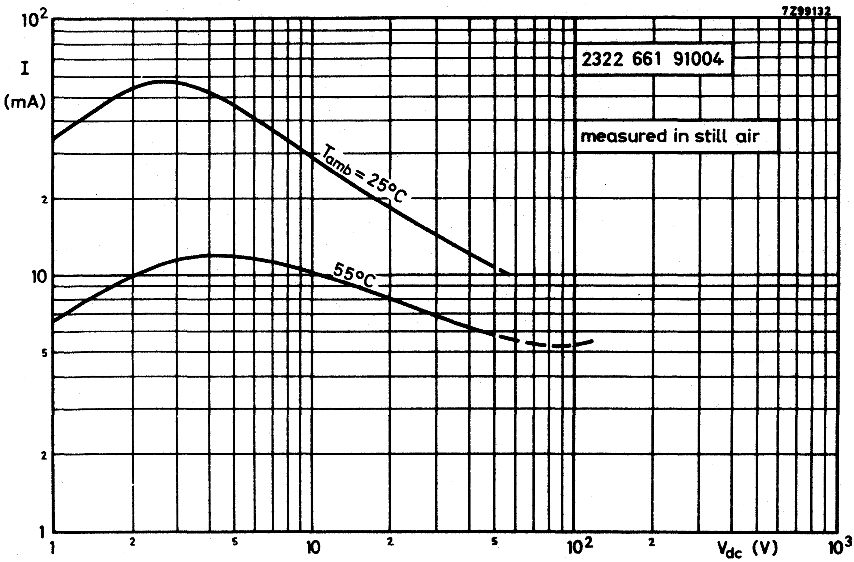


Fig.4c. Voltage/current characteristics

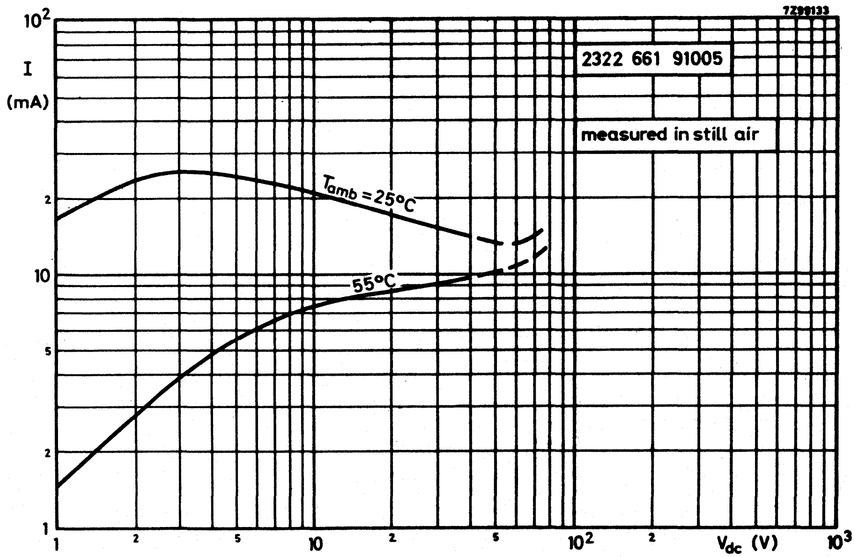


Fig.4d. Voltage/current characteristics

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

Table 3

test	test method	duration	ΔR/R in % at 25 °C	at 3)
Cold at −10 °C	A	1000 h	± 3	± 3
Storage at +25 °C	H	1000 h	± 3	± 3
Dry heat +125 °C	B	1000 h	± 5	± 5
Thermal shock −10 to +125 °C	Na	5 cycles	± 3	± 3
Damp heat	C	1000 h	± 5	± 5
Dissipation at V_{max} 4) and T_{amb} = +55 °C		1000 h	± 5	± 5
Cycle test at V_{max} 4) and T_{amb} = 0 °C		1000 h 1 min on/9 min off	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.
3) At temperatures stated in table 2, second column.
4) V_{max} stated in table 2.

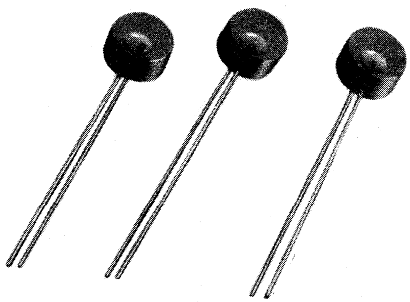
QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D
- A.Q.L. 1 %, major defects - Electrical
- A.Q.L. 1.5 %, major defects - Mechanical
- A.Q.L. 4 %, minor defects - Physical

PACKAGING 250 pieces per box (cardboard)

PTC THERMISTOR

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 approx.
Temperature coefficient	35%/°C approx.
Maximum d.c. voltage	180 V
Dissipation factor	13 mW/°C approx.
Operating temperature range at zero power at maximum d.c. voltage	 0 to + 155 °C 0 to + 55 °C



RZ 27317-11

APPLICATION

This PTC thermistor has been designed for the protection of telegraphy relay contacts.

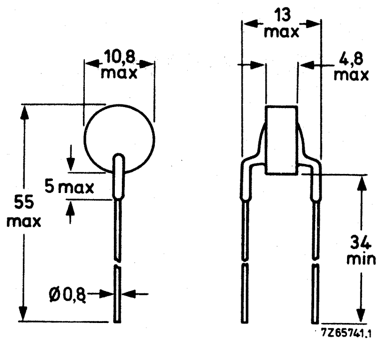
DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Fig. 1



Weight 0,5 g approximately

Mounting In any position by soldering

ELECTRICAL DATA

Resistance at + 25 °C (T_{ref})	36 to 50 Ω [1]
Resistance at + 115 °C	< 120 Ω [1]
Resistance at + 165 °C, V_{pulse} = 180 V	> 20 kΩ [2]
Current at + 25 °C, V_{dc} = 180 V continuously	< 10 mA [3]
Switch temperature	+ 115 °C approx.
Temperature coefficient	35%/°C approx.
Dissipation factor	13 mW/°C approx. [3]
Heat capacity	1 J/°C [3]
Thermal time constant	80 s approx. [3]
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 approx.
Balance voltage	105 V d.c. approx.
Maximum voltage (V_{max}) at + 55 °C	180 V d.c.

1) Measuring voltage not exceeding 1,5 V_{dc} to avoid internal heating.
2) Measurement made without internal heating occurring.
3) Measurement made with specimen in phosphor bronze clips, in still air.

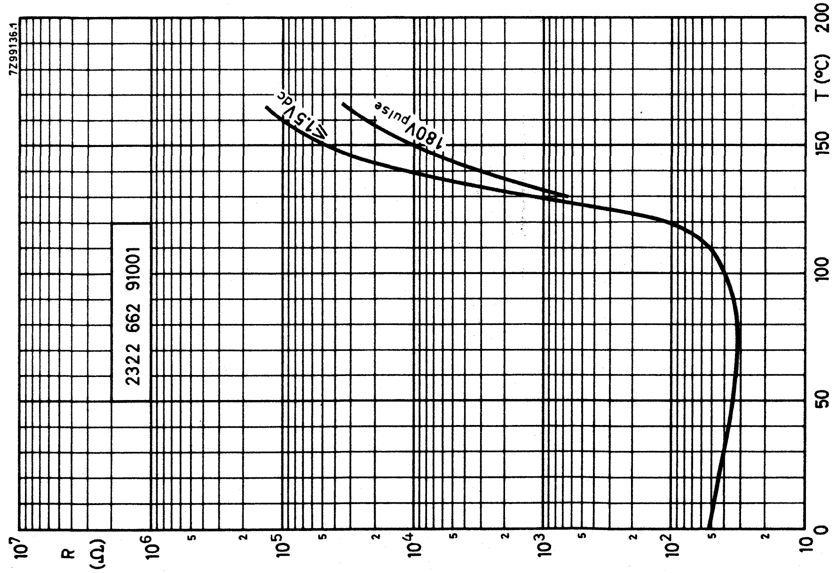


Fig. 2
Typical resistance/temperature characteristics

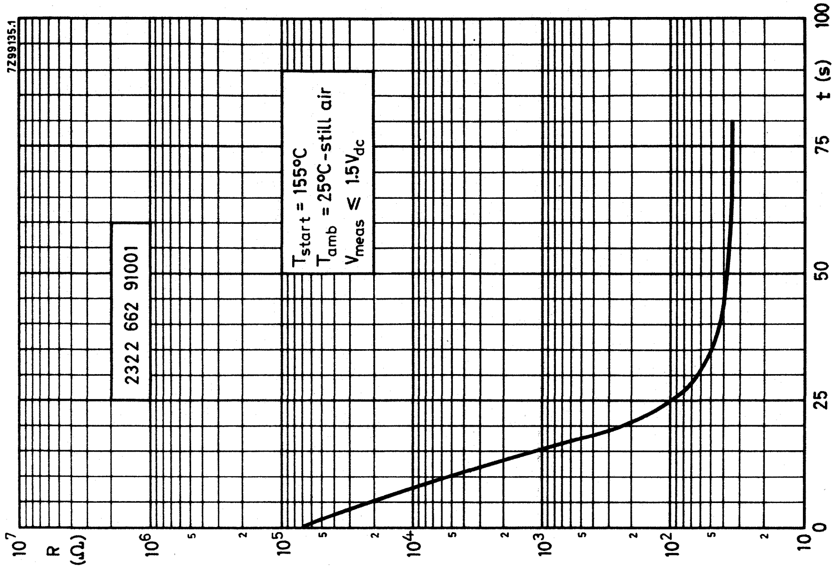


Fig. 3
Typical resistance/time (cooling) characteristic

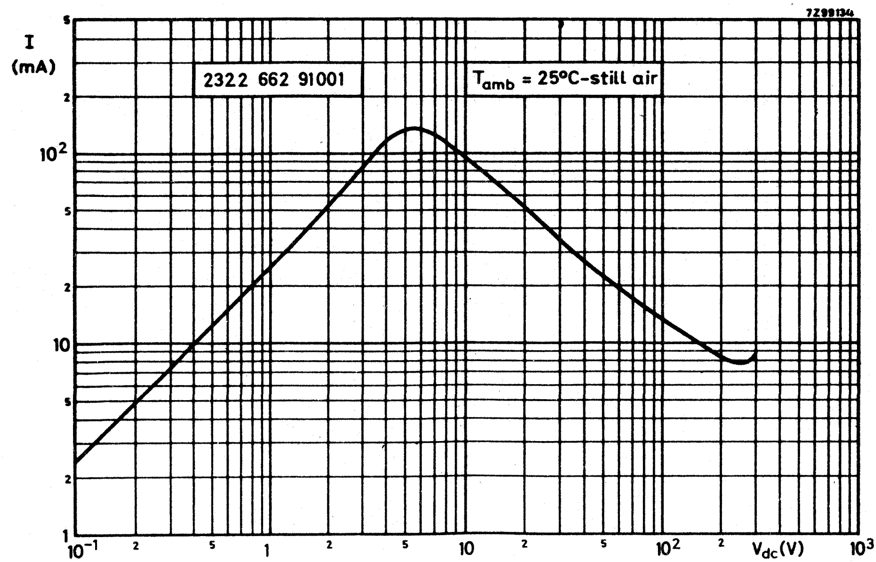


Fig.4. Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +165 °C
Cold at 0 °C	A	168 h	± 3	± 5
Storage at +25 °C	H	1000 h	± 3	± 5
Dry heat at + 155 °C	B	1000 h	± 5	± 10
Thermal shock 0 to + 155 °C	Na	5 cycles	± 3	± 7
Dissipation in damp heat at I = 50 mA d.c. approx. and T_{amb} = +40 °C		2000 h	± 5	± 7,5
Dissipation at V = 180 V d.c. and T_{amb} = +55 °C		1000 h	± 5	± 10
Cycle test at V = 180 V d.c. and T_{amb} = +25 °C		10 cycles [3]	± 5	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s once	[2]	
Resistance to heat	Tb	10 ± 1 s once	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

50 pieces per box (cardboard)

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 provided with two solid tinned brass wires.

MECHANICAL DATA

Dimensions (mm)

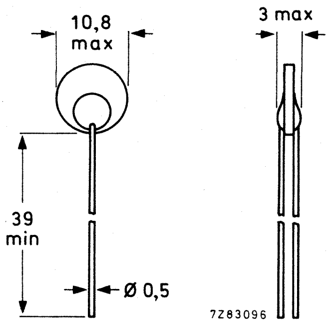


Fig. 1.

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

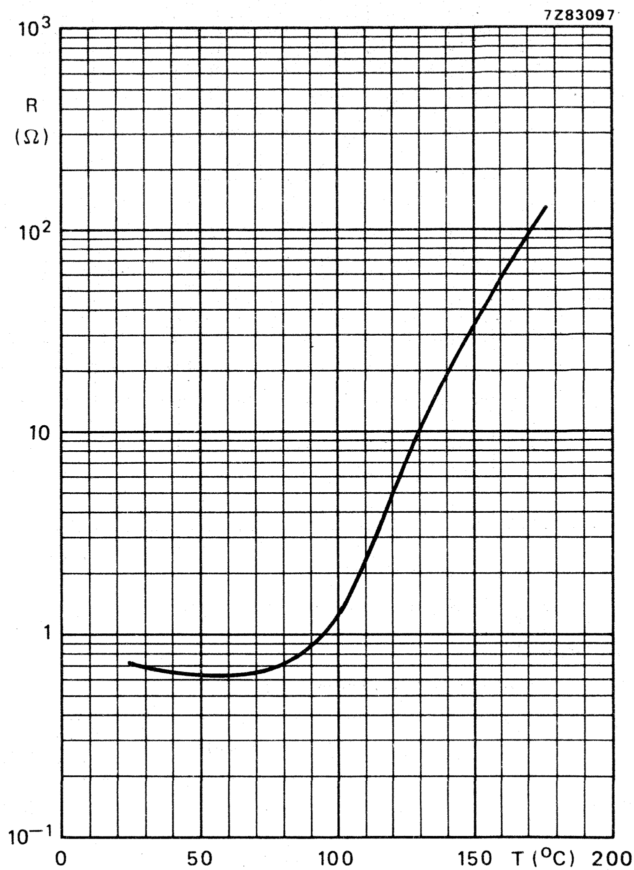


Fig. 2 Typical resistance/temperature characteristic.

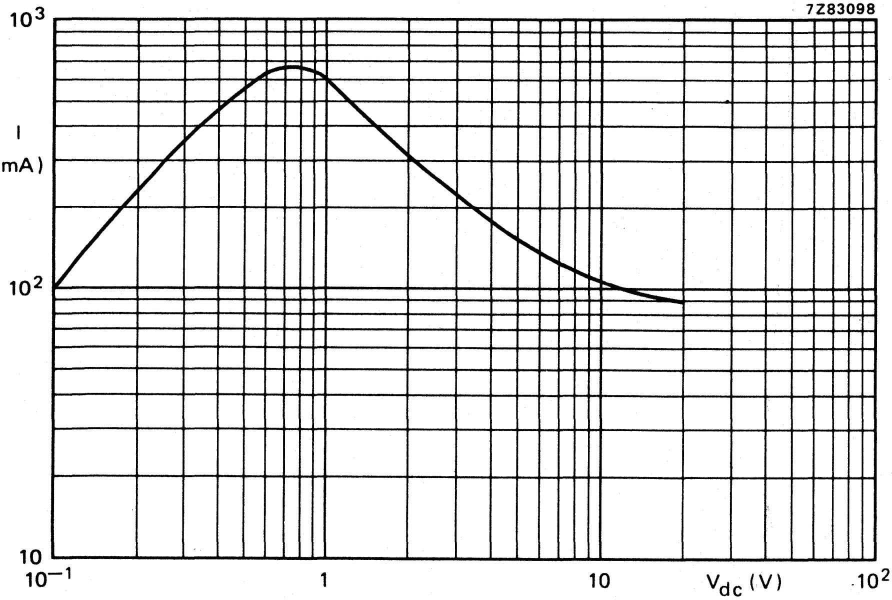


Fig. 3 Typical current/voltage characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C
Dry heat at +155 °C	B	100 h	± 10
Damp heat at +40 °C	C	100 h	± 10
Dissipation at 18 V r.m.s. and T_{amb} = +55 °C		24 h	± 10
Cycle test at 18 V r.m.s. T_{amb} = 0 °C, R_{series} = 8,2 Ω		10 cycles *	± 10

* Cycle: 1 min on/9 min off.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 % — Electrical
A.Q.L. 1,5% — Mechanical

PACKAGING

5000 pieces per box (cardboard).

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 for 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

Dimensions (mm)

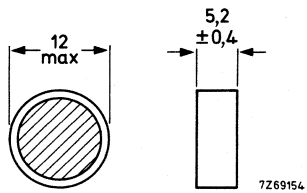


Fig. 1

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

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 *	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

* Measurement made without internal heating occuring.

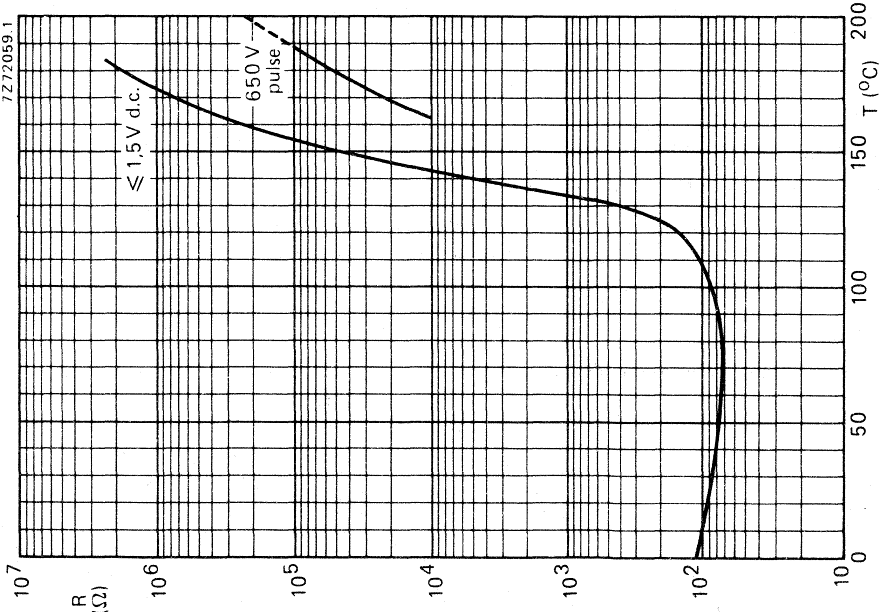


Fig. 2 Typical resistance/temperature characteristics

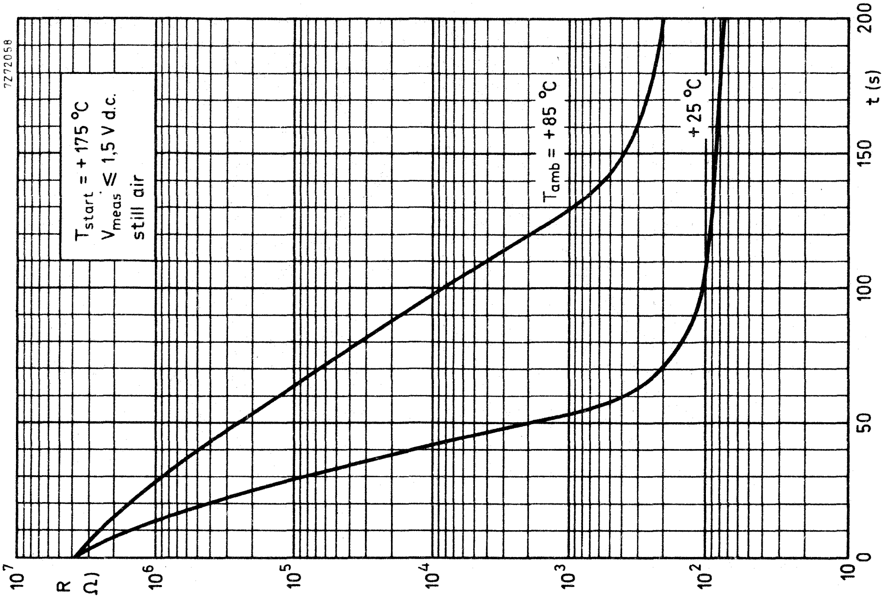


Fig. 3 Typical resistance/time (cooling) characteristics

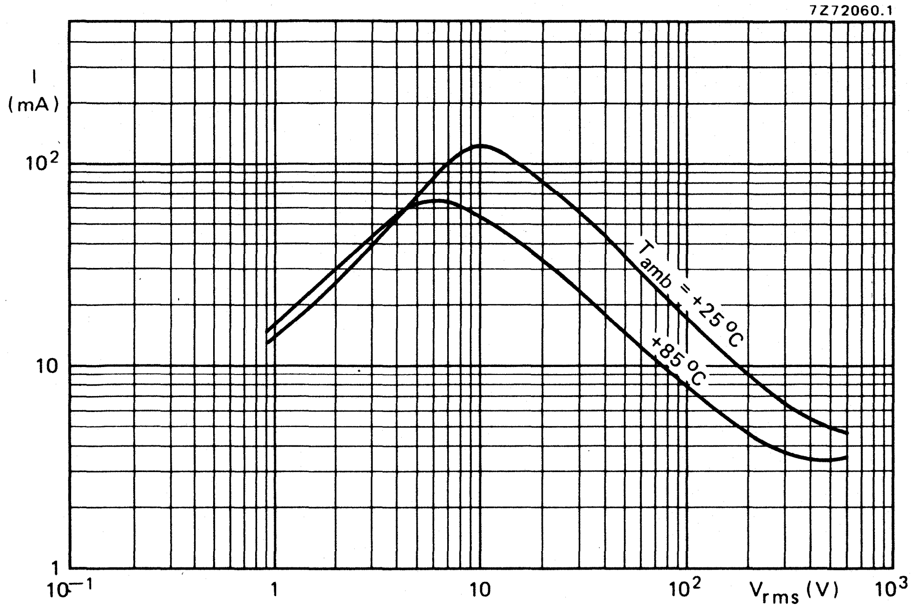


Fig. 4 Typical voltage/current characteristics

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

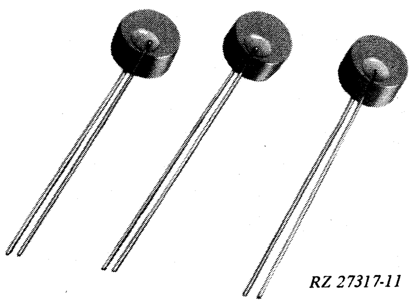
A.Q.L.	1 %	major defects – Electrical
A.Q.L.	1,5%	major defects – Mechanical
A.Q.L.	4 %	minor defects – Physical

PACKAGING

Plastic blister pack containing 60 items.

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at + 25 °C	45 to 60 Ω
Resistance value at + 150 °C V_{pulse} = 340 V	>45 kΩ
Switch temperature	+ 75 °C approx
Temperature coefficient	+ 20 %/deg C approx.
Max. voltage at $T_{amb} \leq 60$ °C	265 V_{rms}
Dissipation factor	20 mW/deg C approx.
Operating temperature range at zero power at V_{max}	 -25 to + 155 °C 0 to + 60 °C



RZ 27317-11

APPLICATION

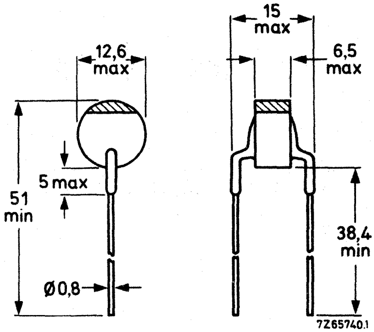
Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm



Marking Green colour band on top of the body.

Weight 4,5 g approximately

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

ELECTRICAL DATA

Resistance at +25 °C	45 to 60 Ω [1]
Resistance at +75 °C	< 160 Ω [1]
Resistance at +150 °C, V_{pulse} = 340 V	> 45 kΩ [2]
Switch temperature	+75 °C approx.
Temperature coefficient	+20%/°C approx.
Dissipation factor	20 mW/°C approx. [3]
Heat capacity	2,2 J/°C approx. [3]
Thermal time constant	110 s approx. [3]
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 approx.
Balance voltage	200 V d.c. approx.
Maximum voltage	265 V r.m.s.

[1]) Measuring voltage not exceeding 1,5 V_{dc} to avoid internal heating.
[2]) Measurement made without internal heating occurring.
[3]) Measurement made with specimen in phosphor bronze clips, in still air.

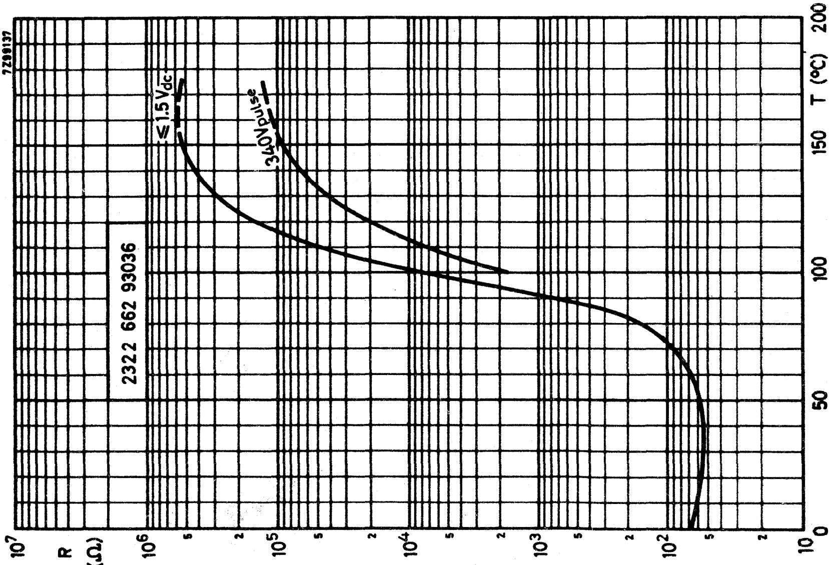


Fig. 2.
Typical resistance/temperature characteristics (no internal heating)

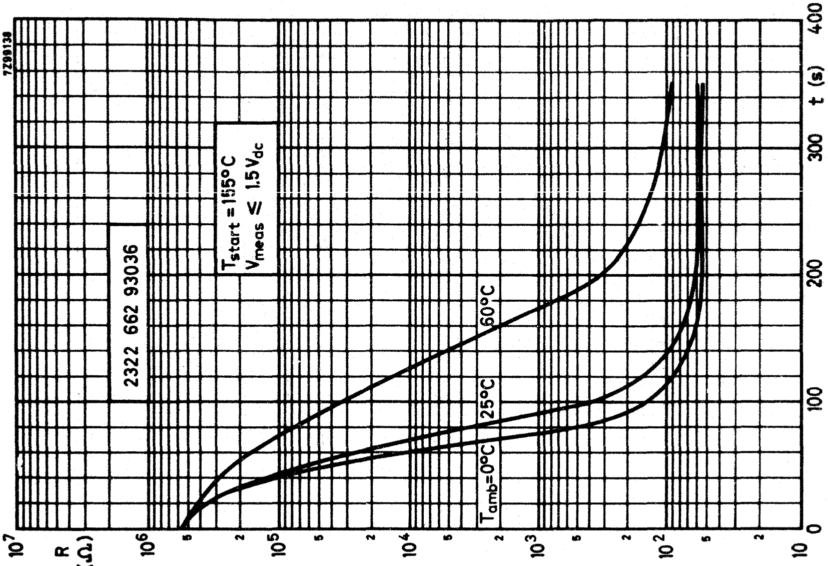


Fig. 3.
Typical resistance/time (cooling) characteristics

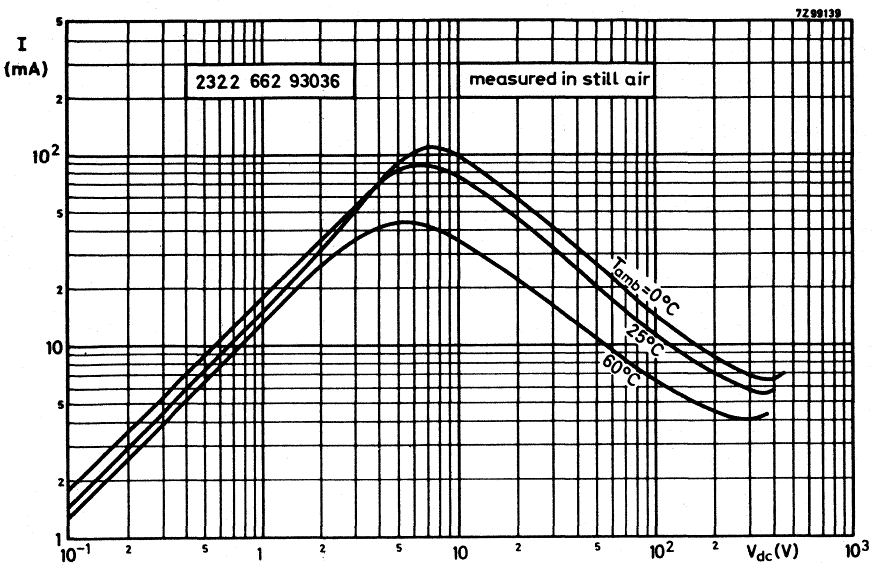


Fig.4. Typical voltage/current characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	at +150 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at + 155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to + 155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at + 40 °C	C	1000 h	± 10	± 12
Dissipation at 265 V r.m.s. and T_{amb} = + 60 °C		1000 h	± 10	± 12
Cycle test at 265 V r.m.s and T_{amb} = 0 °C		100 cycles [3][4]	± 10	± 12
and T_{amb} = 25 °C		2000 cycles [3][4]	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Bending 10 N	Ub	2 times	[1]	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) With series resistor of 33 Ω ± 5%.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

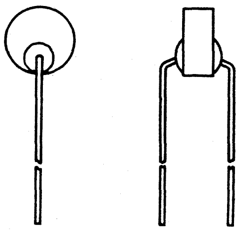
A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

100 pieces per box (cardboard).

PTC THERMISTOR

QUICK REFERENCE DATA	
Resistance value at +25 °C	100 Ω ± 20%
Resistance value at +155 °C V_{pulse} = 380 V	≥ 40 kΩ
Switch temperature	75 °C
Maximum r.m.s. voltage	265 V
Dissipation factor	15 mW/°C approx.
Operating temperature range at zero power at V_{max}	 −25 to +155 °C 0 to +60 °C



APPLICATION

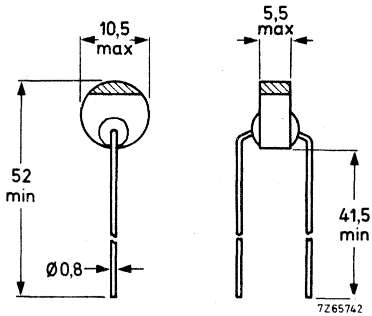
Intended primarily to be used in the degaussing circuit of colour television sets.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)



Marking

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

Weight

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

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

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

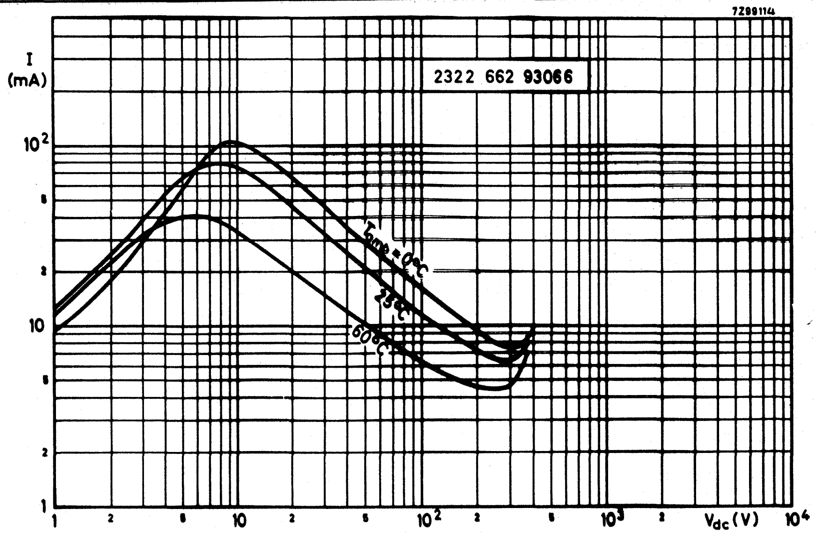


Fig.4 Typical voltage/current characteristics

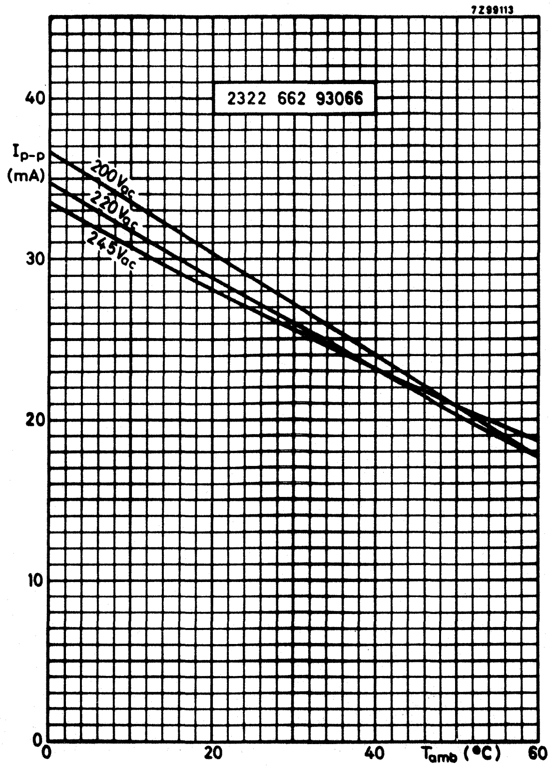


Fig.5 Typical characteristics of peak to peak current against the ambient temperature at different voltages.

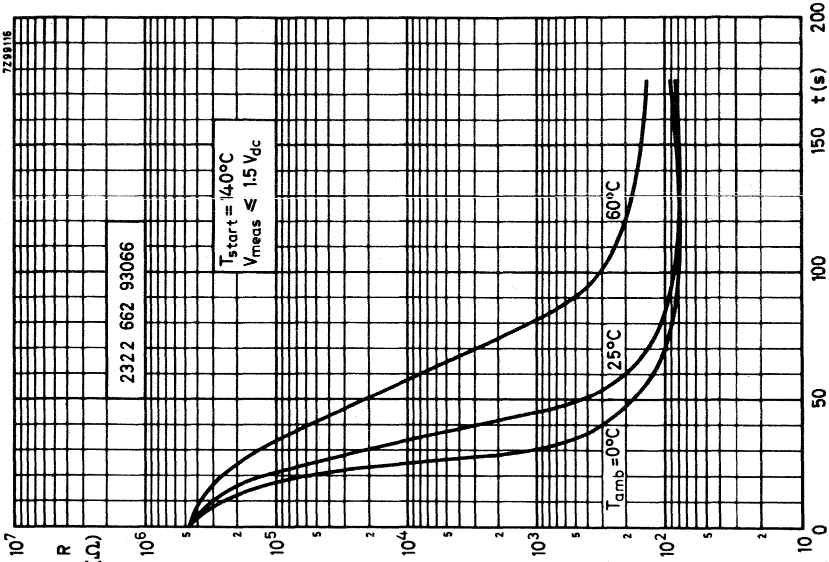


Fig. 3.
Typical resistance/time (cooling) characteristics

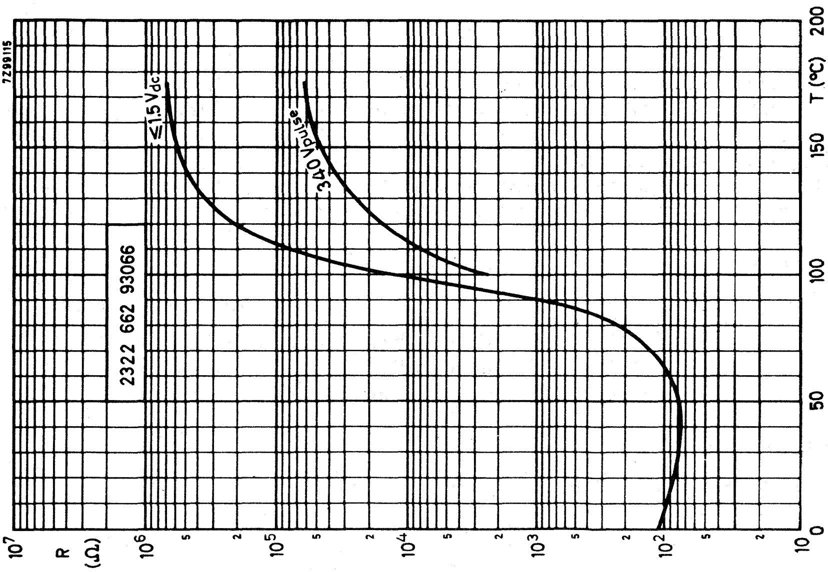


Fig. 2.
Typical resistance/temperature characteristics

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +150 °C
Cold at −25 °C	A	1000 h	±7,5	±12
Storage at +25 °C	H	1000 h	±5	±12
Dry heat at +155 °C	B	1000 h	±10	±12
Thermal shock −25 to +155 °C	Na	5 cycles	±7,5	±12
Damp heat at +40 °C	C	1000 h	±10	±12
Dissipation at 265 V r.m.s. and T_{amb} = +60 °C		1000 h	±10	±12
Cycle test at 265 V r.m.s. and T_{amb} = 0 °C		100 cycles 3) 4)	±10	±12
and T_{amb} = +25 °C		2000 cycles 3) 4)	±7,5	±12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	par. 3.2.4	3 to 4 s	±2	±2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) Two PTC's in parallel with a series resistance of 33 Ω ± 5%.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

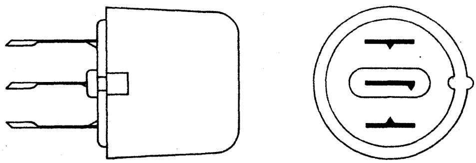
PACKAGING

100 pieces per box (card board).

DUAL PTC THERMISTORS

QUICK REFERENCE DATA

	2322 662 98001	2322 662 98003
Current through the coil measured at	200 V r.m.s	220 V r.m.s.
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 voltage	245 V r.m.s.	265 V r.m.s.
Switch temperature	75 °C	
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum voltage	0 to + 60 °C	



APPLICATION

Intended primarily to be used in the degaussing circuit 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

Dimensions in mm

Point A is to be connected
to the mains
Point C is to be connected
to the degaussing coil

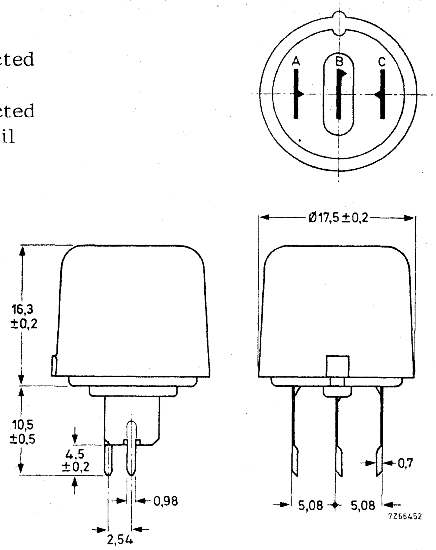


Fig.1

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

ELECTRICAL DATA

	2322 662 98001	2322 662 98003
Current through the coil		
measured in circuit of Fig. 2 at	200 V r.m.s.	220 V r.m.s.
min. inrush 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
Resistance at +25 °C:		
of mains PTC [2]	25 Ω [1]	30 Ω [1]
of coil PTC [2]	8 Ω [1]	8 Ω [1]
at T_{amb} = +175 °C and 345 V pulsed		
of mains PTC [3]	≥32 kΩ	≥35 kΩ
at T_{amb} = +155 °C		
of coil PTC	≥20 kΩ	≥20 kΩ
Switch temperature of mains and coil PTC	75 °C	75 °C
Temperature coefficient		
of mains PTC	23 %/degC [1]	25 %/degC [1]
of coil PTC	25 %/degC [1]	25 %/degC [1]
Balance voltage		
of mains PTC	190 V d.c. [1]	160 V d.c. [1]
Voltage dependency at +155 °C		
of mains PTC	0,28 [1]	0,26 [1]
Maximum voltage in circuit [4]	245 V r.m.s.	265 V r.m.s.
Dissipation factor [4]	13,5 mW/degC [1]	
Thermal time constant [4]	200 s [1]	
Heat capacity of ceramic		
of mains PTC	1,6 J/degC [1]	
of coil PTC	0,47 J/degC [1]	
of complete assembly [4]	2,7 J/degC [1]	
Operating temperature range		
at zero power	−25 to +155 °C	
at maximum voltage	0 to + 60 °C	

1) approximately values
2) Measuring voltage not exceeding 1,5 V d.c. to avoid internal heating
3) Measurements have to be made without self heating of the specimen
4) Measurements made with the thermistor soldered on printed wiring board in still air

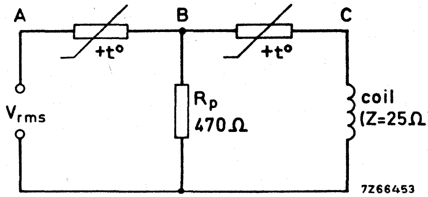


Fig. 2 Measuring circuit.
R_p must be able to withstand a peak power of 25 W for 300 ms.

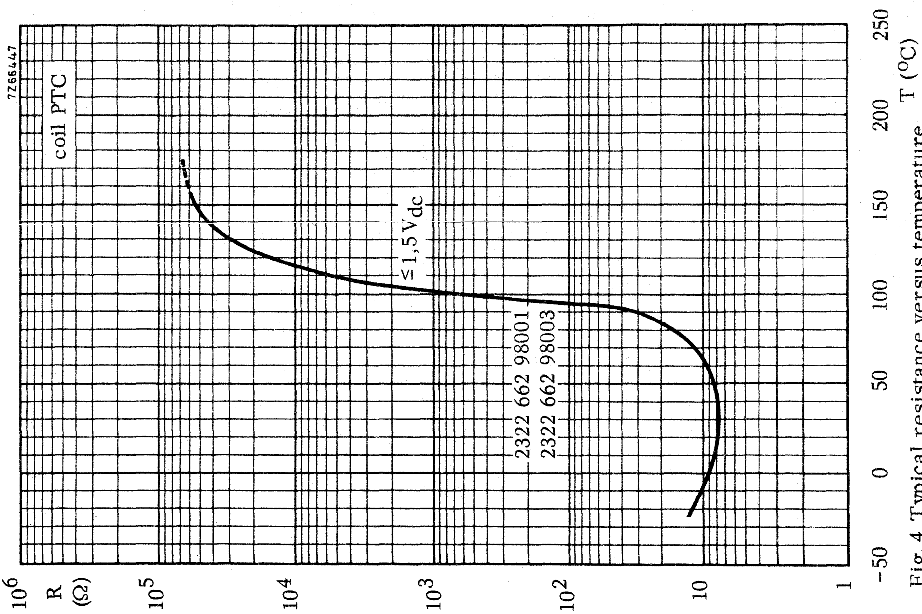


Fig. 4 Typical resistance versus temperature characteristics of the coil PTC thermistor.

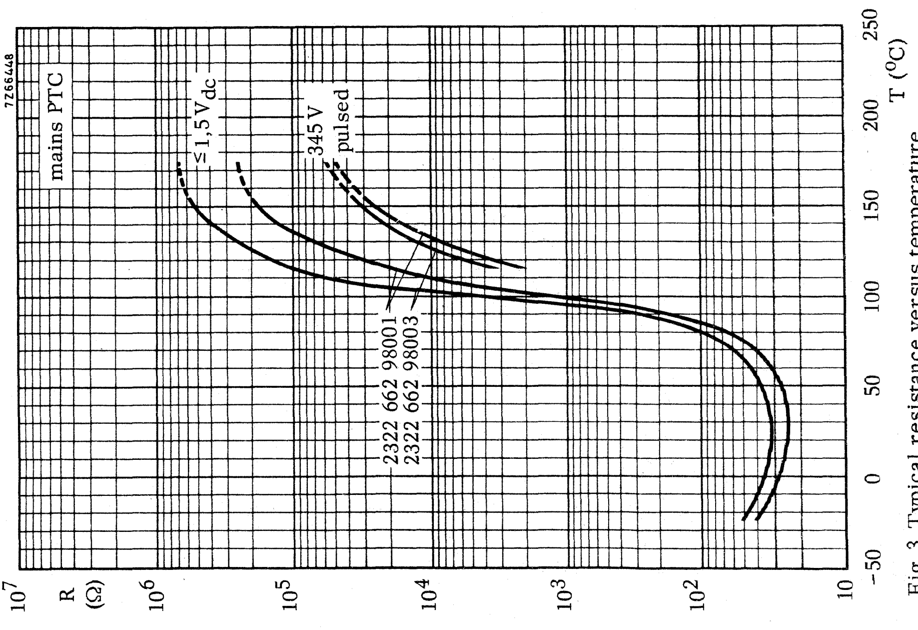


Fig. 3 Typical resistance versus temperature characteristics of the mains PTC thermistor.

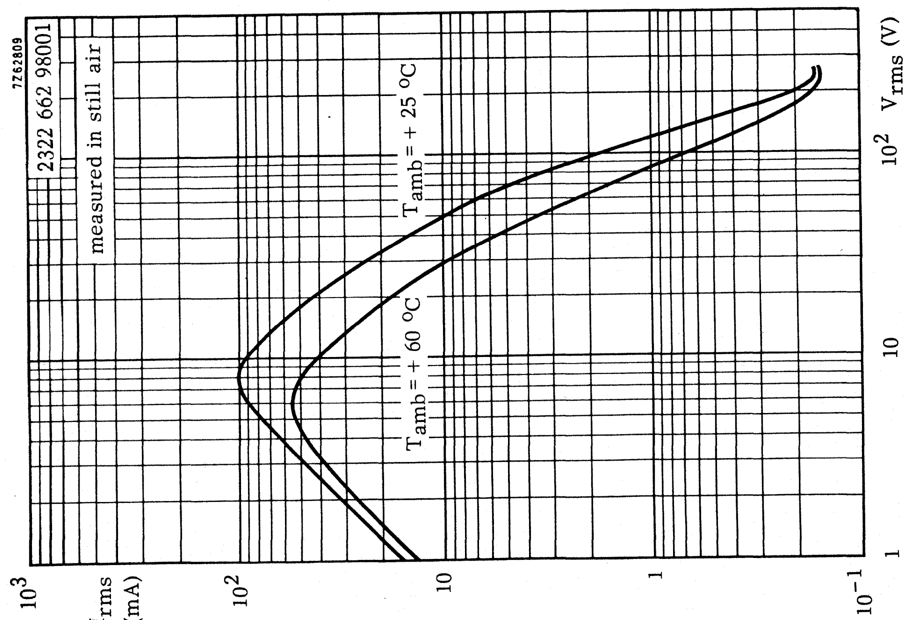


Fig. 5 Typical static current through the coil versus voltage characteristics.

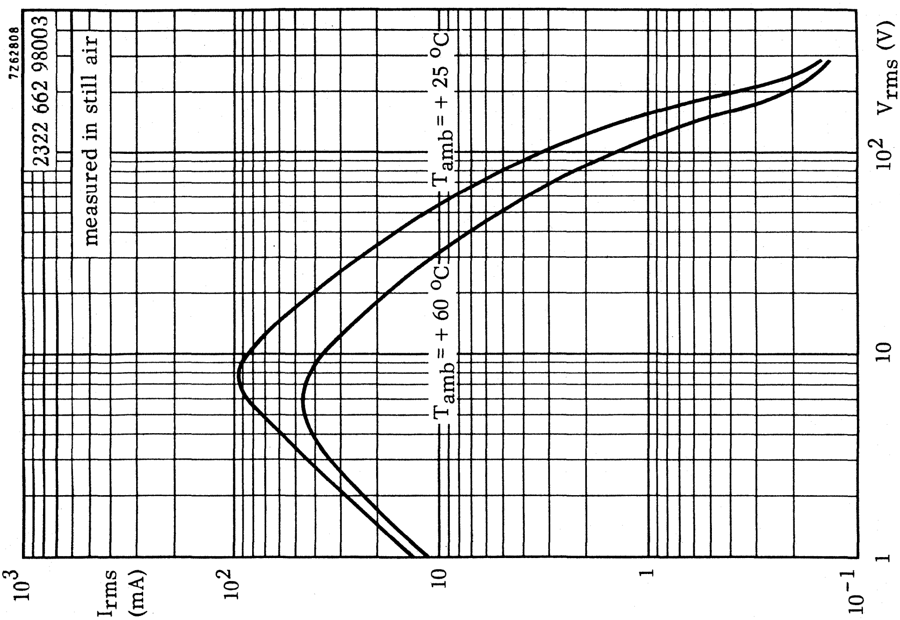


Fig. 6 Typical static current through the coil versus voltage characteristics.

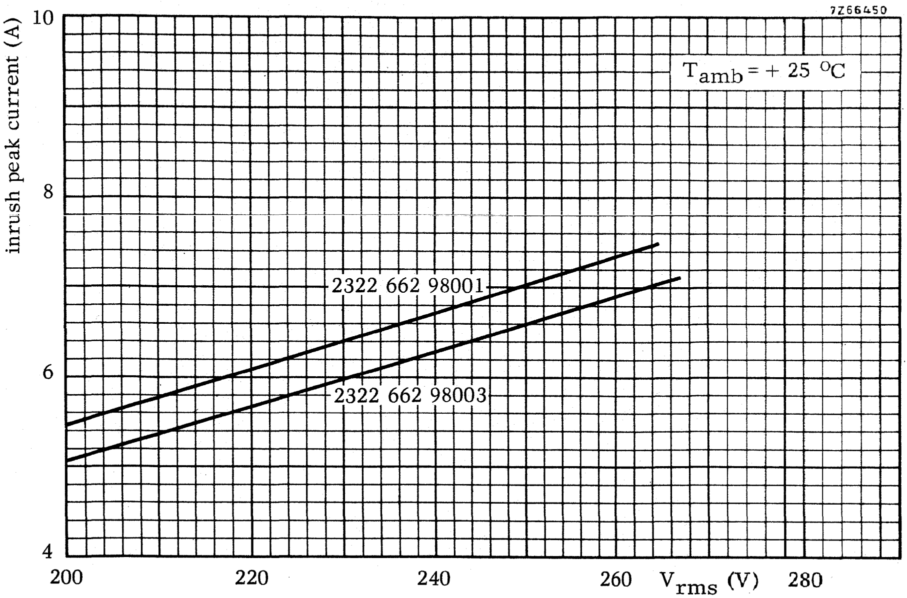


Fig. 7 Typical inrush peak current versus voltage characteristics.

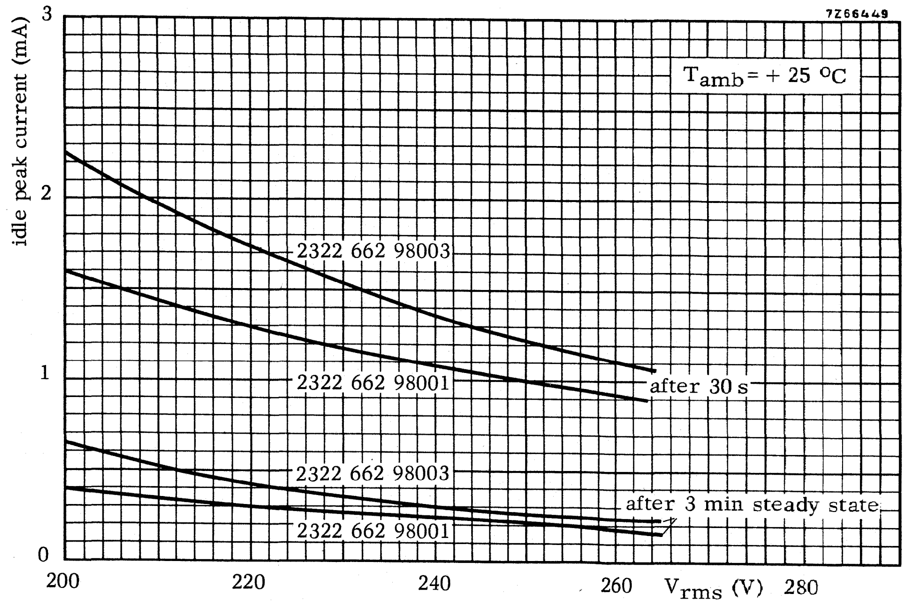


Fig. 8 Typical peak idle current versus voltage characteristics.

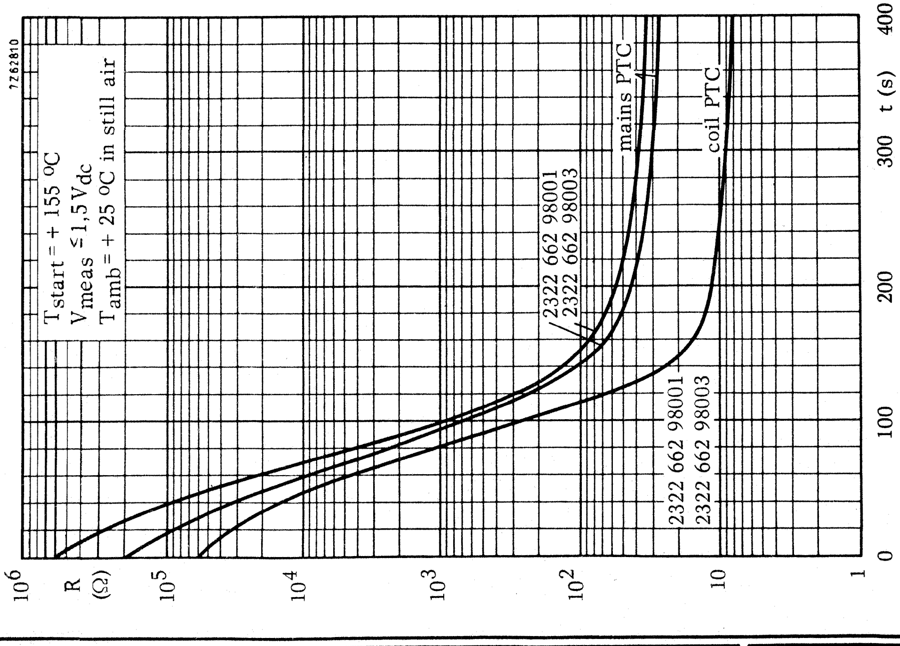


Fig. 9 Typical resistance versus cooling time characteristics of mains PTC thermistor.

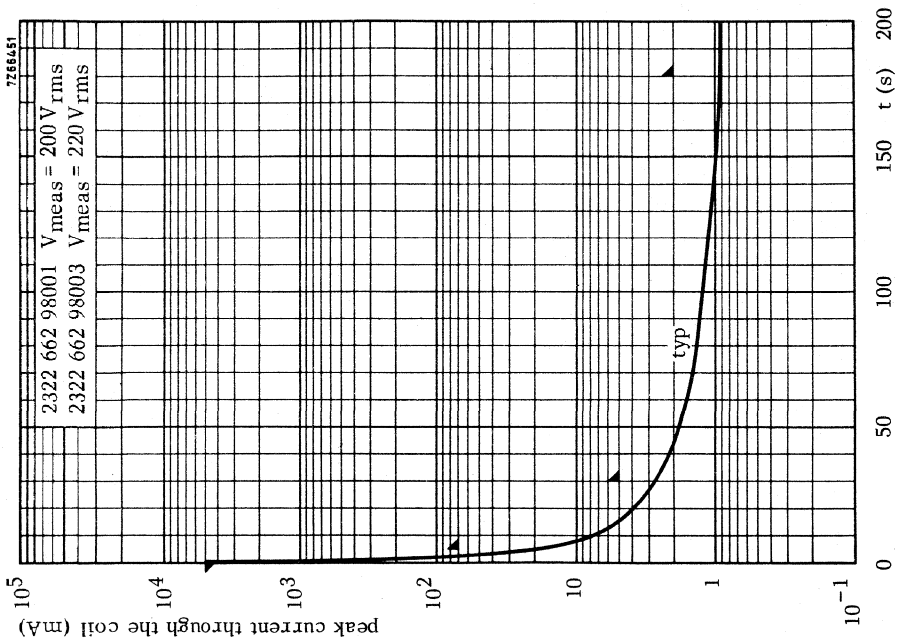


Fig. 10 Typical peak current through the coil versus time characteristic.

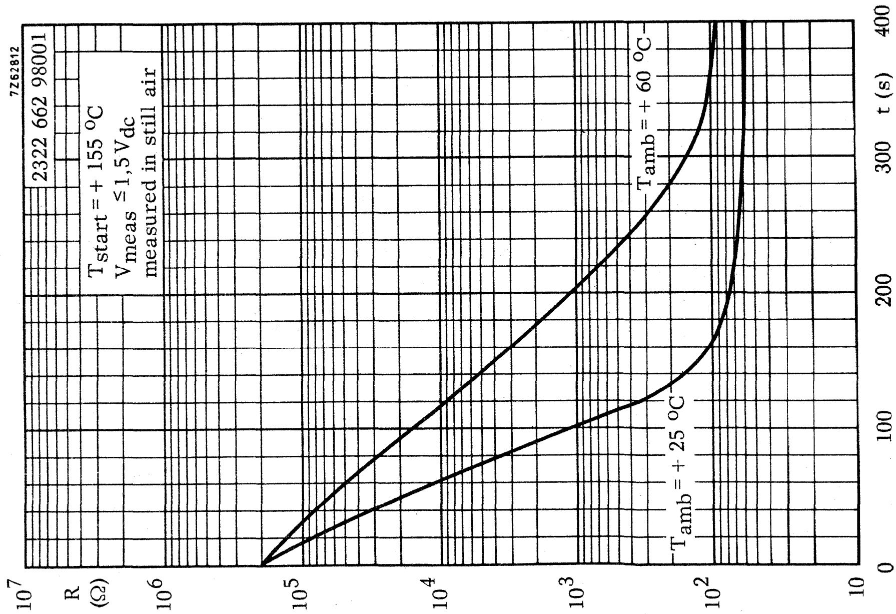


Fig. 11 Typical resistance of circuit versus cooling time characteristics.

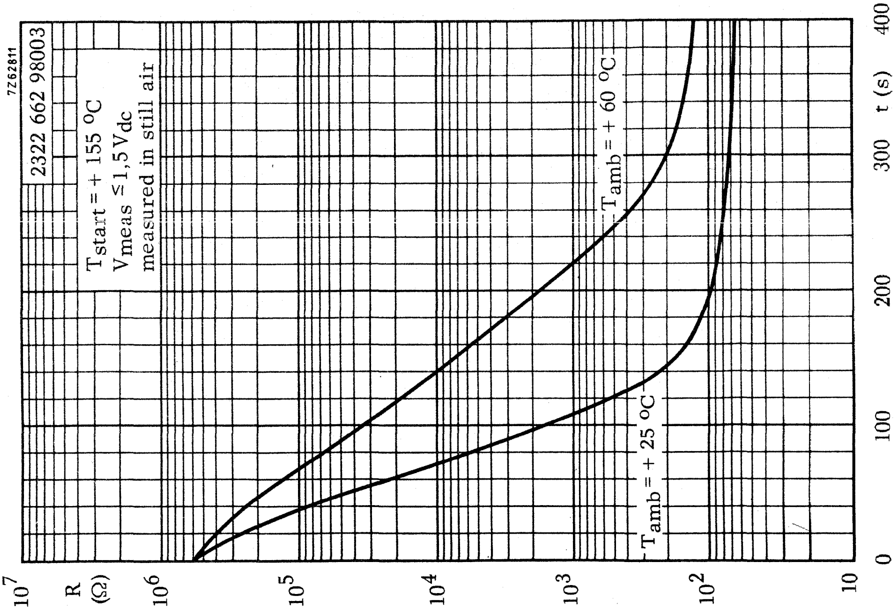


Fig. 12 Typical resistance of circuit versus cooling time characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +125 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 245 V (r.m.s.) and T_{amb} = +60 °C		1000 h	± 10	± 12
Cycle test at 245 V (r.m.s.) and T_{amb} = 0 °C		100 cycles [3]	± 10	± 12
and T_{amb} = +25 °C		2000 cycles [3]	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	[1]	
Soldering	T			
Solderability	par. 3.2.3.	3 to 4 s	[2]	
Resistance to heat	Tb	10 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	[4]	

1) Pins should neither come loose nor break.
2) Pins must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

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

Intended primarily to be used in the degaussing circuit 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 plastic housing of which the cap is white and the base blue. 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

Dimensions (mm)

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

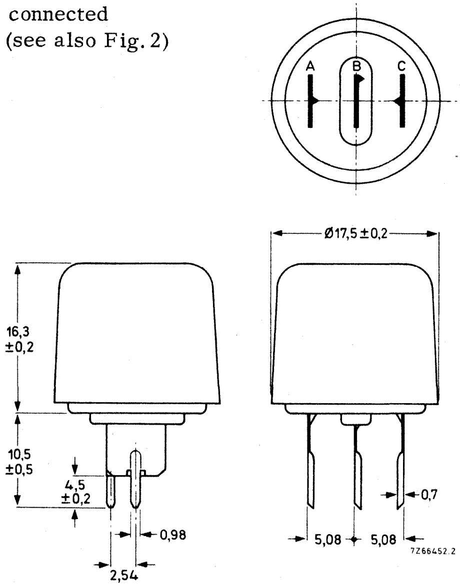


Fig. 1

Marking	The catalogue number is moulded in the top of the cap
Weight	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 IEC draft publication 50 (secretariat) 209.

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 [1]
R_p	1000 to 6000 Ω [1]
Maximum r.m.s. voltage in circuit [2]	265 V
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum voltage	0 to + 60 °C

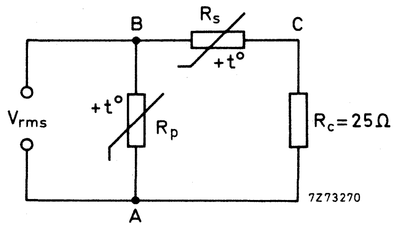


Fig. 2. Measuring circuit
R_p = parallel PTC
R_s = series PTC
R_c replaces the degaussing coil (Z = 25 Ω)

[1] Approximate values.
[2] Measurements made with the thermistor soldered on printed-wiring board in still air.

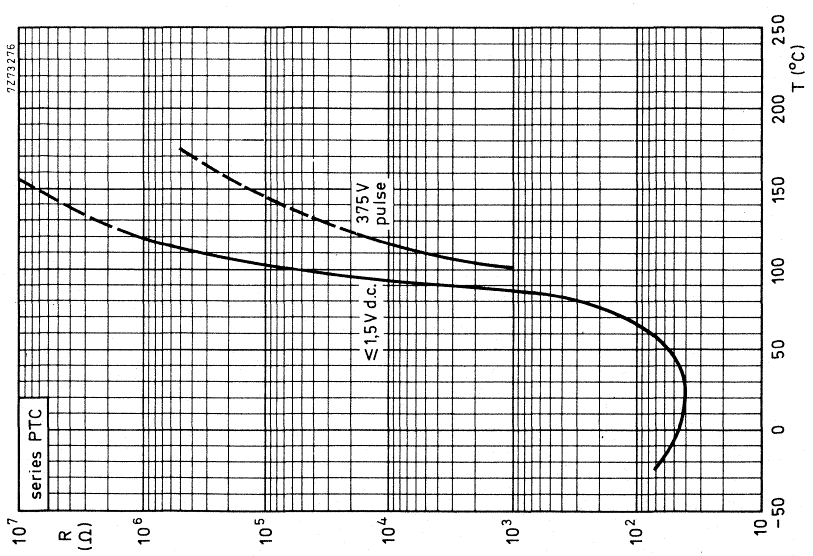


Fig. 3. Typical resistance versus temperature characteristics of the series PTC

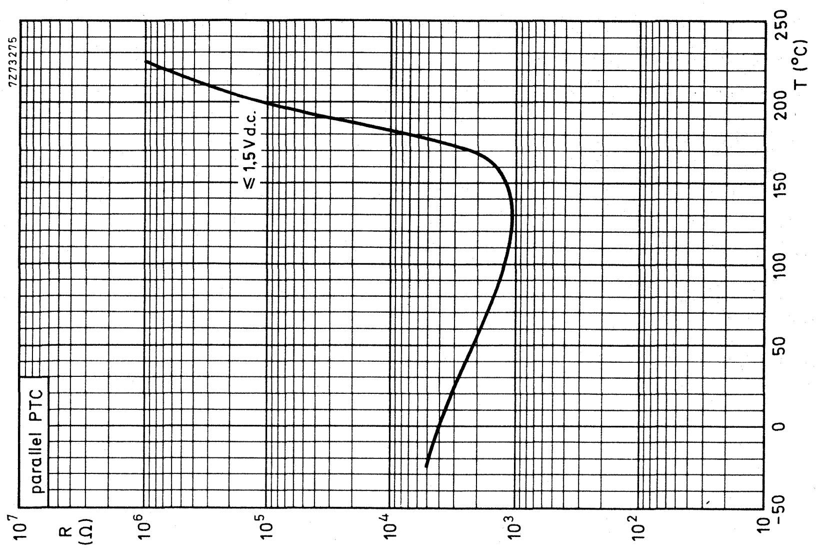


Fig. 4. Typical resistance versus temperature characteristics of the parallel PTC

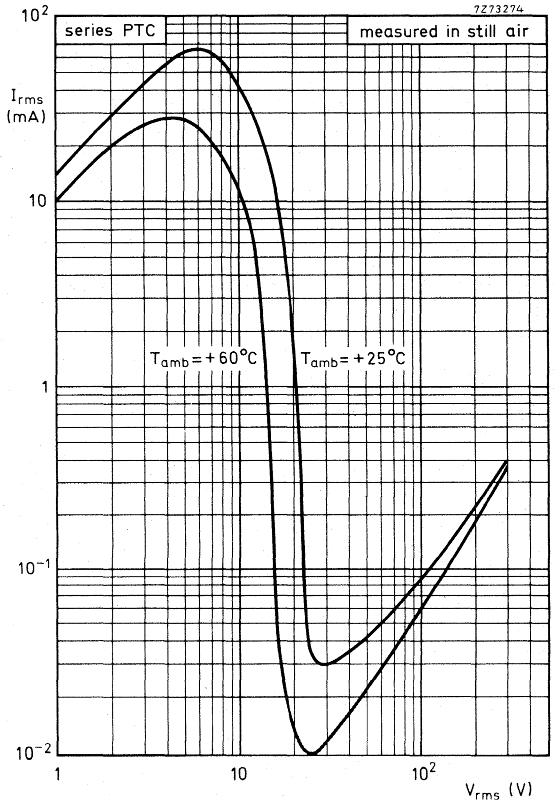


Fig. 5. Typical static current through the coil versus voltage characteristics

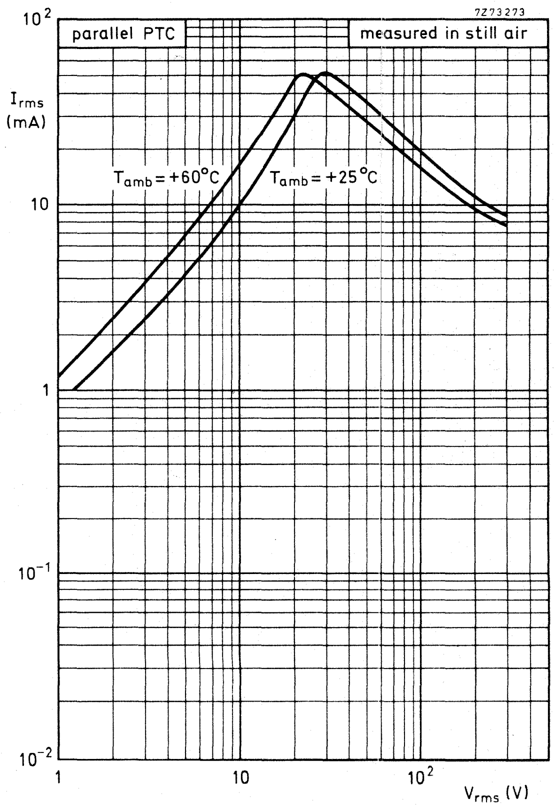


Fig. 6. Typical static current through the parallel PTC versus voltage characteristics

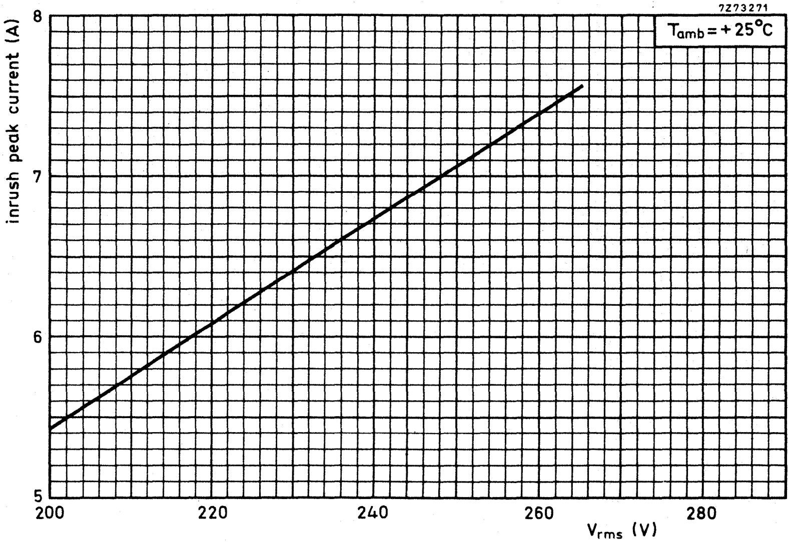


Fig. 7. Typical inrush peak current versus voltage characteristic

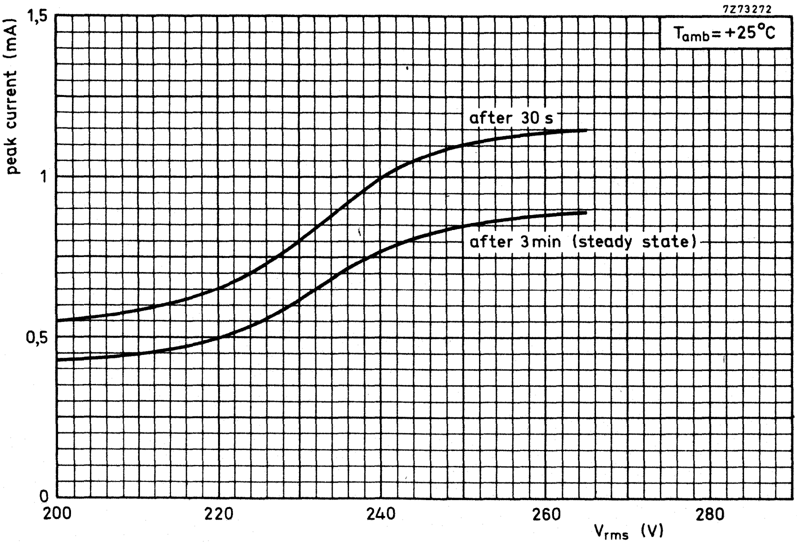


Fig. 8. Typical peak current versus voltage characteristics

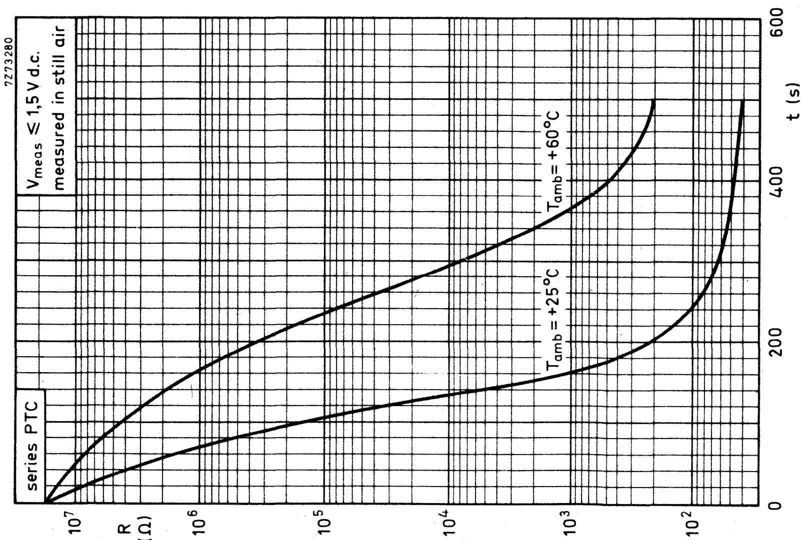


Fig. 9. Typical resistance versus cooling time characteristics of series PTC (cooling off after stationary operation at 220 V).

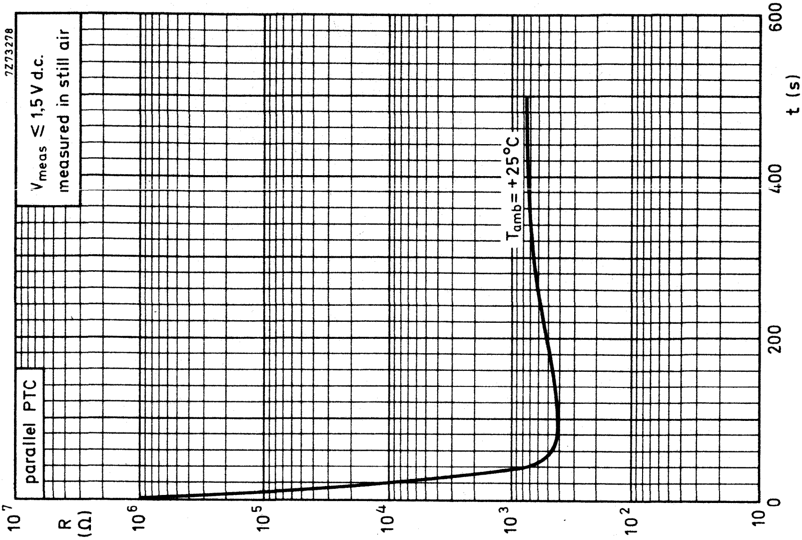


Fig. 10. Typical resistance versus cooling time characteristic of parallel PTC (cooling off after stationary operation at 220 V).

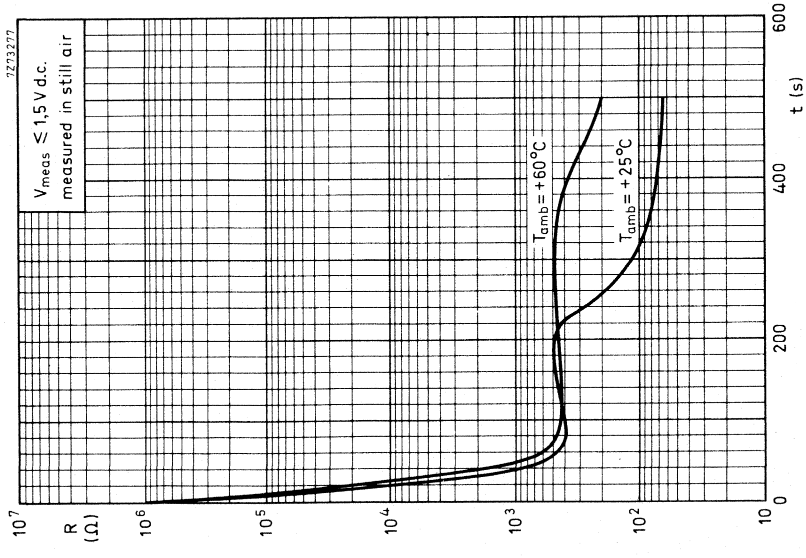


Fig. 11. Typical resistance of circuit versus cooling time characteristics (cooling off after stationary operation at 220 V).

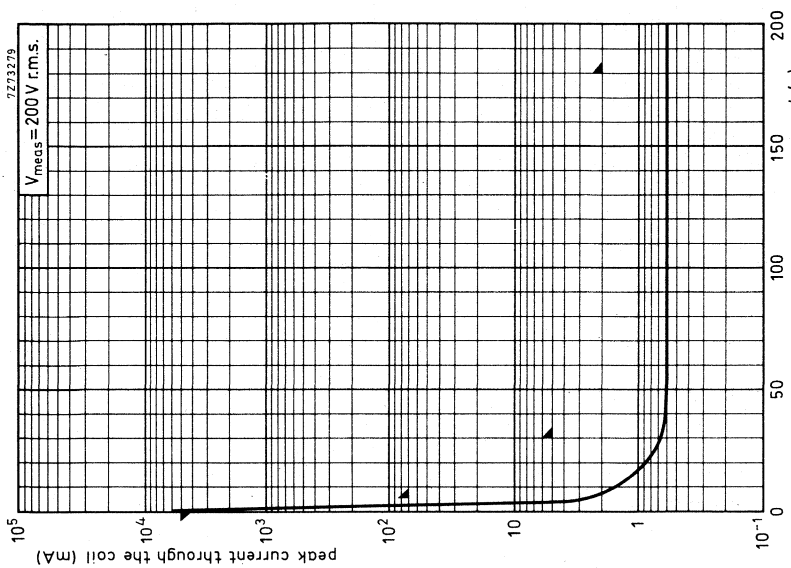


Fig. 12. Typical peak current through the coil versus time characteristic. Peak current limits are indicated by ◢

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +125 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +125 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +125 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation at 265 V r.m.s. and T_{amb} = +60 °C		1000 h	± 10	± 12
Cycle test at 265 V r.m.s. and T_{amb} = 0 °C		100 cycles 3) 4)	± 10	± 12
and T_{amb} = +25 °C		2000 cycles 3) 4)	± 7,5	± 12
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	2)	
Resistance to heat	T_b	10 to 11 s	± 2	± 2
Impact	E			
Free fall	Ed	2 falls	4)	

1) Pins should neither come loose nor break.
2) Pins must be solderable initially and after 6 months storage with solder containing resin flux.
3) Cycle: 1 min on/9 min off.
4) There should be no visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

600 pieces per box (cardboard).

PTC - NTC THERMISTOR

QUICK REFERENCE DATA

Current through the coil at 200 V r.m.s.	
min. inrush peak current	5,8 A
max. peak current	
after 5 s	70 mA
after 30 s	12 mA
after 3 min	5 mA
Resistance of NTC at + 25 °C	130 Ω ± 20%
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum voltage	0 to + 60 °C

APPLICATION

Intended primarily to be used in the degaussing circuit and as surge protection for switch-mode power supply in colour television sets.

DESCRIPTION

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

MECHANICAL DATA

Dimensions in mm

Pin A to be connected to the load,
pin B to the mains,
pin C to the degaussing coil.
See also Fig. 2.

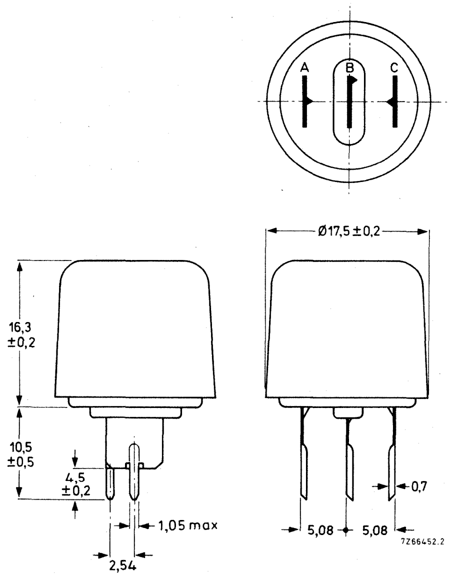


Fig. 1.

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, in accordance with MIL-STD-202, method 111.

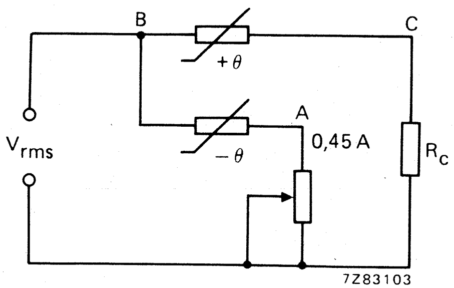
ELECTRICAL DATA

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

Current through the coil measured in circuit of Fig. 2 at 200 V r.m.s.	
min. inrush current	5,8 A
max. idle peak current	
after 5 s	70 mA
after 30 s	12 mA
after 3 min	5 mA
Supply voltage range (r.m.s.)	187 to 265 V
Coil resistance	min. 17 Ω
Dissipation factor	12,5 mW/K
Thermal time constant	225 s
Operating temperature range	−25 to + 125 °C

	PTC	NTC
Resistance at + 25 °C	40 Ω	130 Ω ± 20%
at T_{amb} = + 175 °C and 375 V pulsed	⩾ 130 kΩ	
Switch temperature	+ 65 °C	
Temperature coefficient	+ 26%/K	
B-value		max. 3700 K
Max. current		
at 187 V r.m.s.		1,4 A
at 265 V r.m.s.		1 A
Min. current		0,45 A
Balance voltage (d.c.)	150 V	
Voltage dependency at + 175 °C	0,20	

Fig. 2 Measuring circuit.
BC = PTC thermistor
BA = NTC thermistor
R_c = 17,2 Ω ± 1% (replaces degaussing coil)
T_{amb} = + 25 °C



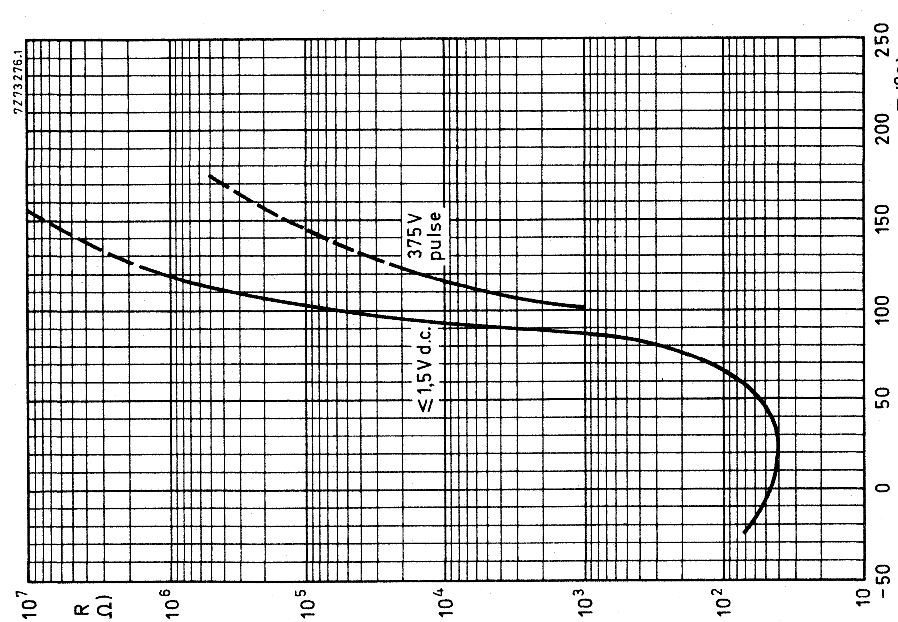


Fig. 3 Typical resistance versus temperature characteristics of the PTC thermistor.

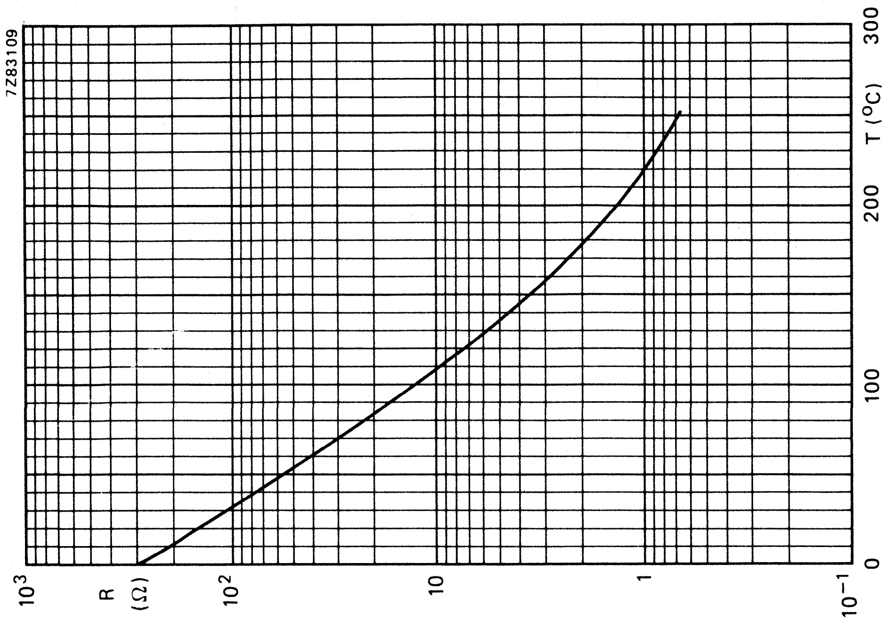


Fig. 4 Typical resistance versus temperature characteristic of the NTC thermistor.

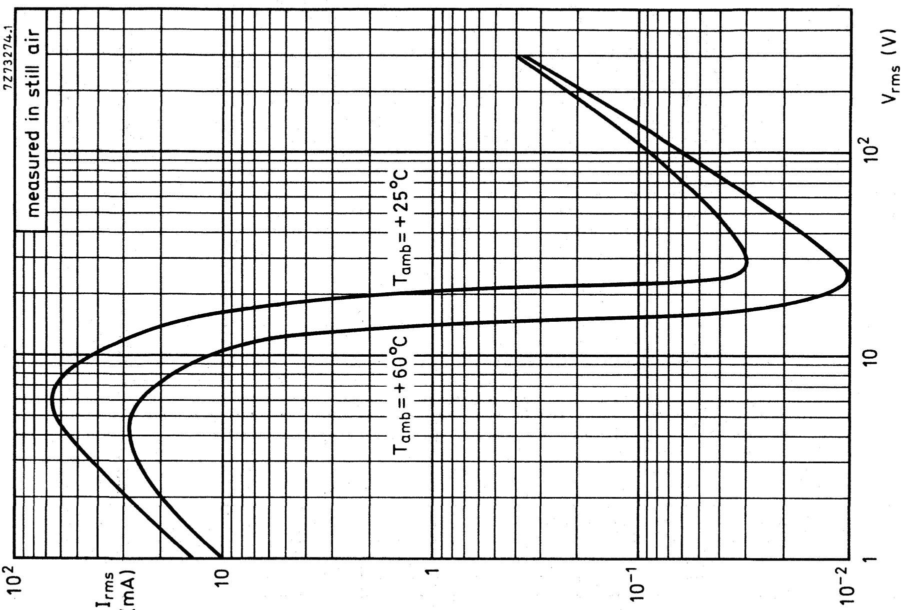


Fig. 5 Typical static current through the coil versus voltage characteristics.

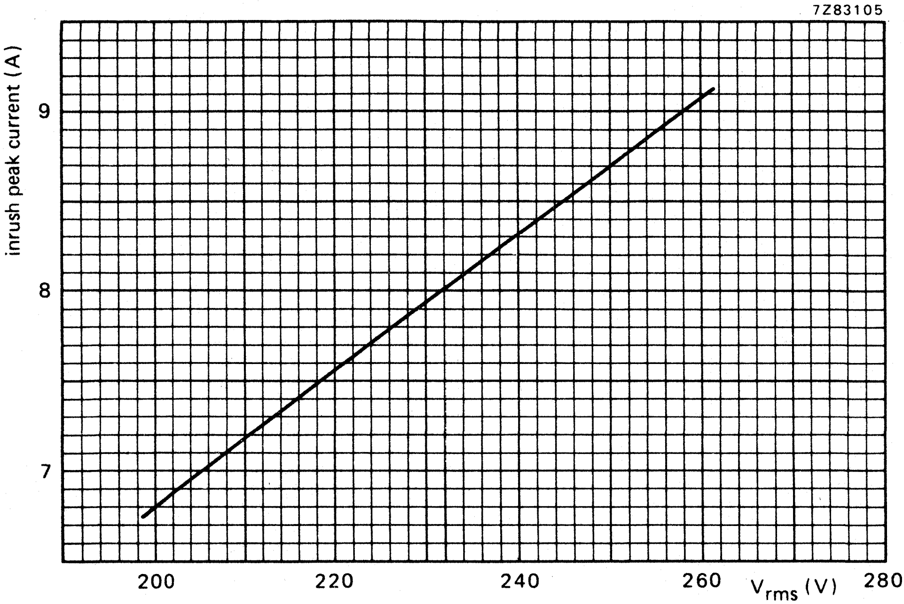


Fig. 6 Typical inrush peak current versus voltage, at T_{amb} = + 25 °C.

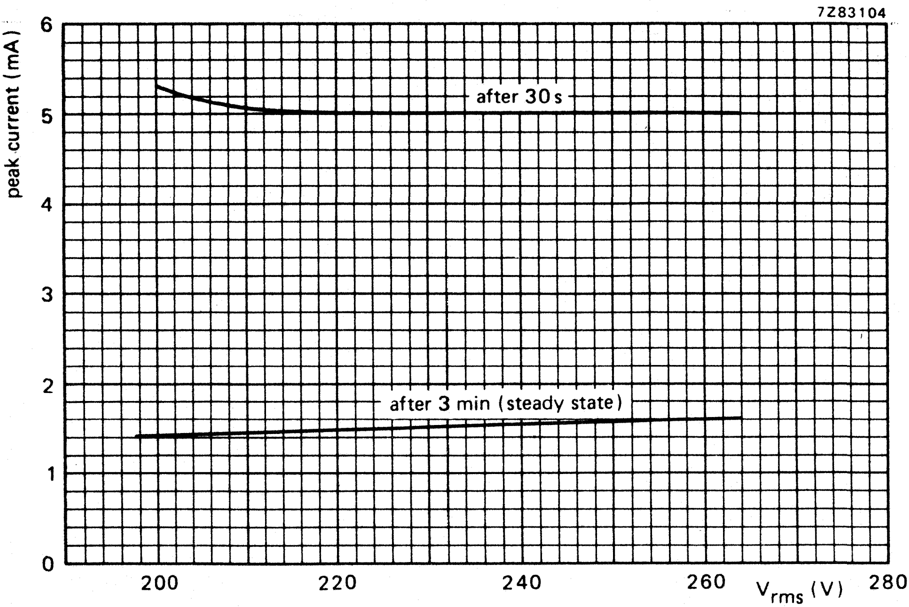


Fig. 7 Typical peak current versus voltage characteristics, at T_{amb} = + 25 °C.

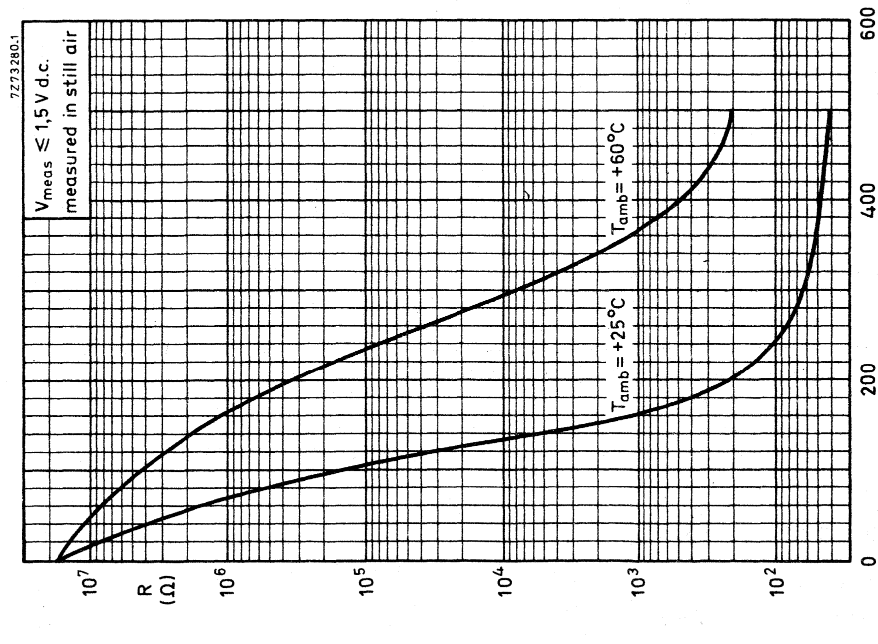


Fig. 8 Typical resistance versus cooling time characteristics of PTC. T_{start} = + 175 °C.

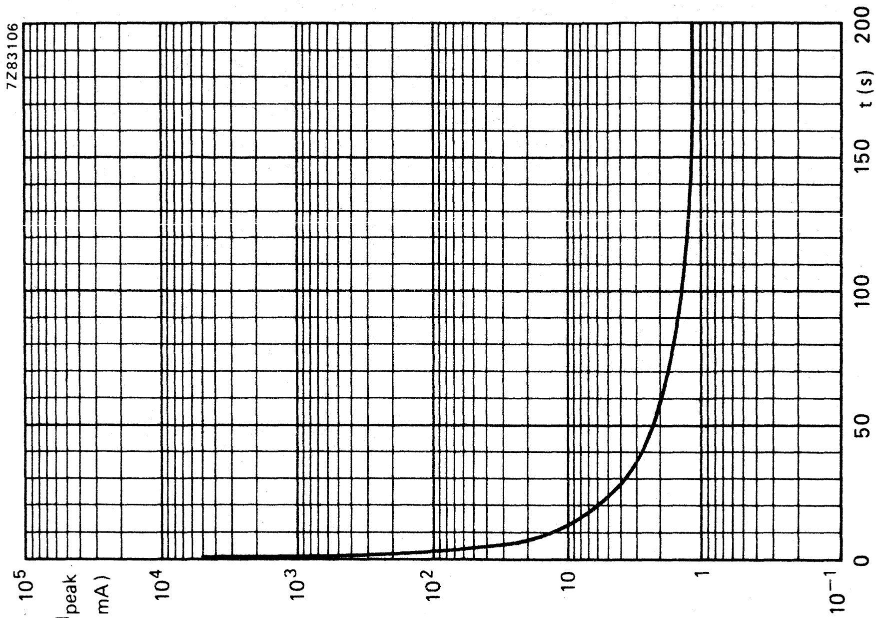


Fig. 9 Typical peak current through the coil versus time characteristic. V_{meas} = 200 V r.m.s.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at −25 °C	A	1000 h	
Storage at + 25 °C	H	1000 h	
Dry heat at + 125 °C	B	1000 h	
Thermal shock −25 to + 125 °C	Na	5 cycles	
Damp heat at + 40 °C	C	1000 h	
Dissipation at T_{amb} = + 60 °C, V_{rms} = 265 V, I_{NTC} = 1,4 A		1000 h	
Cycle test at 187 V r.m.s., I_{NTC} = 1,4 A	note 3		
at T_{amb} = 0 °C		100 cycles	
at T_{amb} = + 25 °C		2000 cycles	
Cycle test at 265 V r.m.s., I_{NTC} = 1 A	note 3		
at T_{amb} = 0 °C		100 cycles	
at T_{amb} = + 25 °C		2000 cycles	
Quick cycle test at 187 V r.m.s., I_{NTC} = 1,4 A and T_{amb} = + 25 °C	note 5	10 cycles	
Robustness of terminations	U		
Tensile strength 20 N	Ua	10 s	note 1
Soldering	T		
Solderability	par. 3.2.3	3 to 4 s	note 2
Resistance to heat	T_b	10 to 11 s	± 2
Impact	E		
Free fall	Ed	2 falls	note 4

Notes
1. Leads should neither come loose nor break.
2. Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3. Cycle: 1 min on/9 min off.
4. There should be no visual and electrical defects.
5. Cycle: 5 s on/5 s off after preheating for 4 min.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, Electrical
A.Q.L. 1,5%, Mechanical
A.Q.L. 0,25%, Inoperatives

PACKAGING

500 pieces per box (cardboard).

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.)	140 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

Intended primarily to be used 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

Dimensions in mm

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

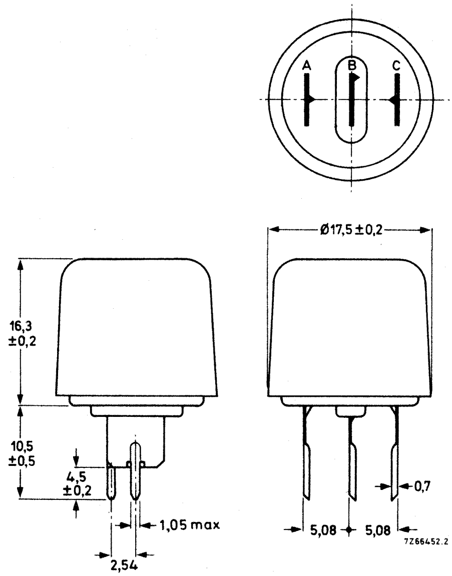


Fig. 1.

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, 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	140 V
Operating temperature range	
at zero power	–25 to + 125 °C
at maximum voltage	0 to + 60 °C

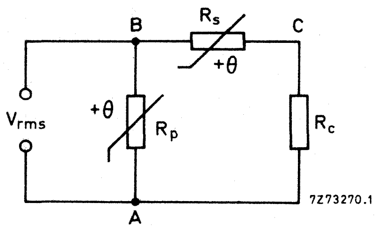


Fig. 2 Measuring circuit.
R_p = parallel PTC
R_s = series PTC
R_c = 6,2 Ω (replaces degaussing coil)

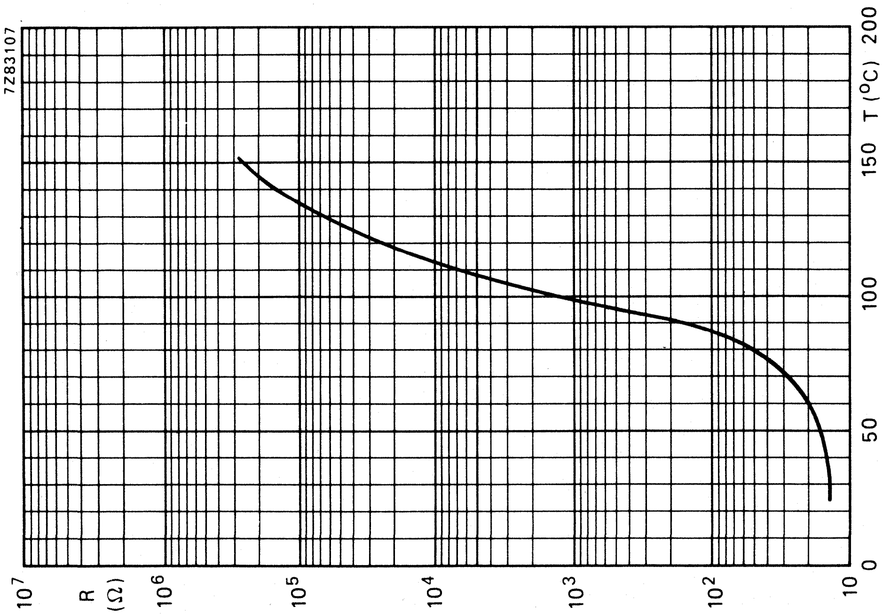


Fig. 3 Series PTC.

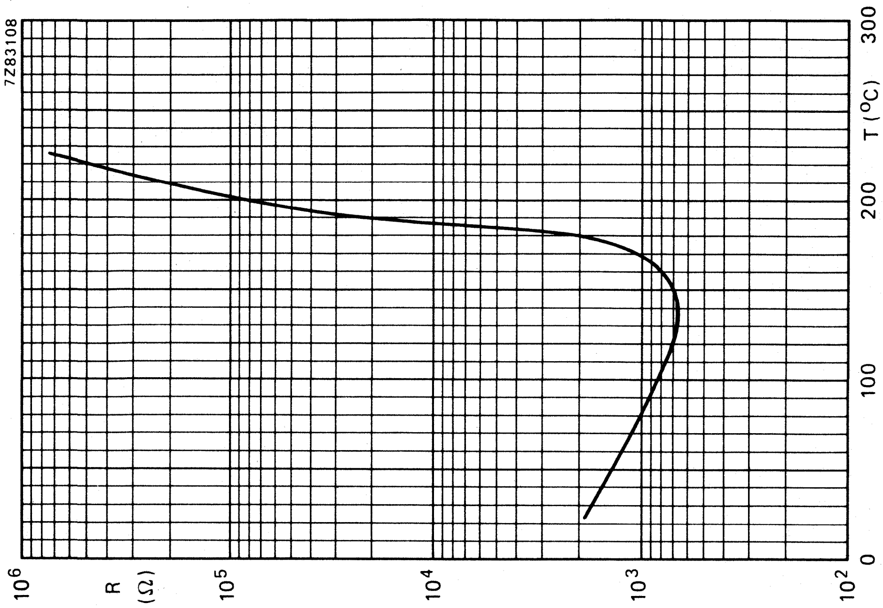


Fig. 4 Parallel PTC.

Typical resistance/temperature characteristics.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at –25 °C	A	1000 h	min. inrush peak current and max. idle peak current will not be exceeded by more than 5%
Storage at + 25 °C	H	1000 h	
Dry heat at + 125 °C	B	1000 h	
Thermal shock –25 to + 125 °C	Na	5 cycles	
Damp heat at + 40 °C	C	1000 h	
Dissipation at 140 V r.m.s. and T_{amb} = + 60 °C	note 1	1000 h	
Cycle test at 140 V r.m.s.	note 1		
and T_{amb} = 0 °C		100 cycles (note 2)	
and T_{amb} = + 25 °C		2000 cycles (note 2)	
Robustness of terminations	U		
Tensile strength 20 N	Ua	10 s	note 3
Soldering	T		
Solderability	par. 3.2.3	3 to 4 s	note 4
Resistance to heat	Tb	10 to 11 s	see above line
Impact	E		
Free fall	Ed	2 falls	note 5

Notes:
1. With series resistor of 6,2 Ω ± 5%.
2. Cycle: 1 min on/9 min off.
3. Pins should neither come loose nor break.
4. Pins must be solderable initially and after 6 months storage with solder containing resin flux.
5. Neither electrical nor visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, Electrical
A.Q.L. 1,5%, Mechanical
A.Q.L. 0,25%, Inoperative

PACKAGING

500 pieces per box (cardboard).

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 provided with two solid tinned brass wires.

MECHANICAL DATA

Dimensions in mm

Outlines

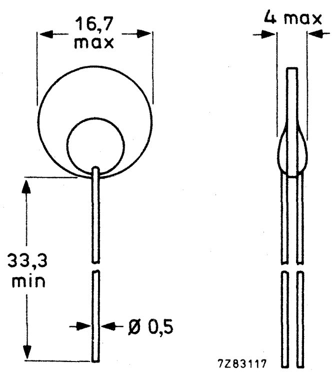


Fig. 1.

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

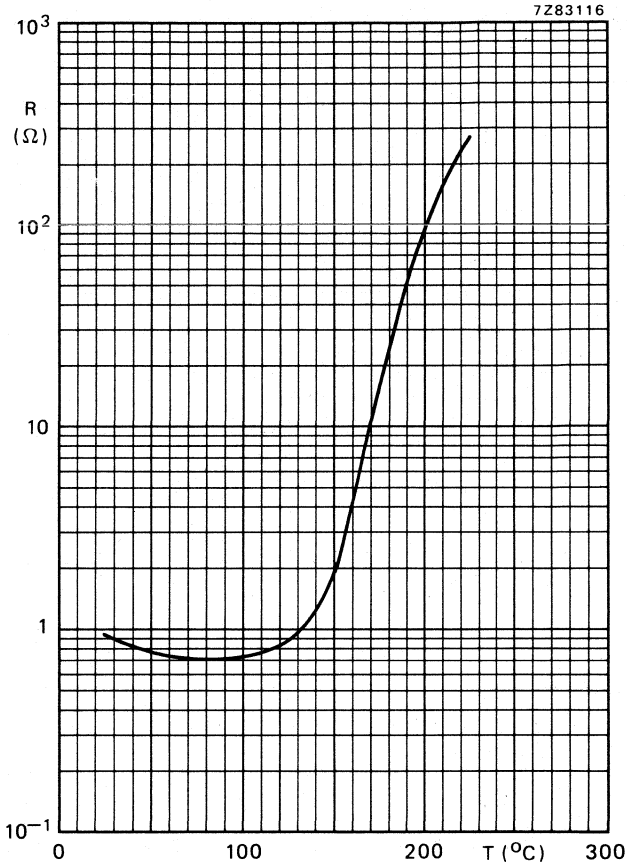


Fig. 2 Typical resistance/temperature characteristic.

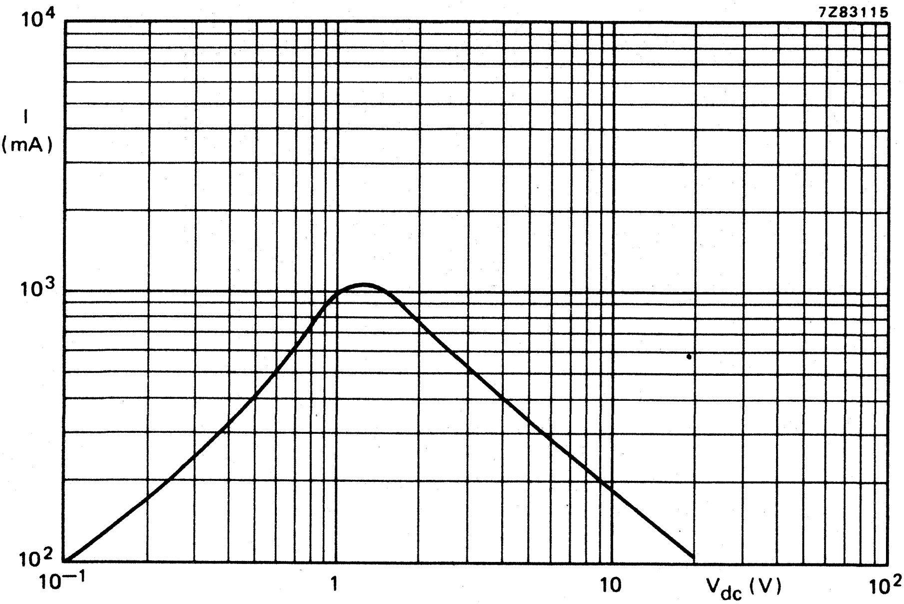


Fig. 3 Typical voltage/current characteristic.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations, unless otherwise specified.

test	test method	duration	ΔR/R (%) at + 25 °C
Dry heat at + 175 °C	B	100 h	± 10
Damp heat at + 40 °C	C	100 h	± 10
Dissipation at V_{rms} = 18 V and T_{amb} = + 85 °C		24 h	± 10
Cycle test at V_{rms} = 18 V and T_{amb} = 0 °C	note 1	10 cycles note 2	± 10

Notes: 1. With series resistor of 4,7 Ω ± 5%.
2. Cycle: 1 min on/9 min off.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1%, major defects – Electrical
A.Q.L. 1,5%, major defects – Mechanical

PACKAGING

2000 pieces per box (cardboard).

PTC THERMISTOR
disc

QUICK REFERENCE DATA	
Resistance value at +25 °C	14 to 26 Ω
Resistance value at +200 °C V_{pulse} = 345 V	min. 20 kΩ
Switch temperature	+ 125 °C
Temperature coefficient	+28%/°C
Maximum r.m.s. voltage	245 V
Dissipation factor	21 mW/°C
Operating temperature range at zero power at maximum voltage	 −25 to + 175 °C 0 to + 80 °C

APPLICATION

Suitable for all kinds of applications, e.g. overheat protection in the ballast of a fluorescent lamp system.

DESCRIPTION

This positive temperature coefficient thermistor consists of a disc provided with two solid tinned copper wires. The body is neither lacquered nor insulated.

MECHANICAL DATA

Dimensions (mm)

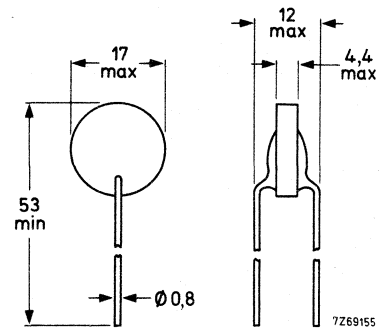


Fig. 1

Marking	None
Weight	4,3 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
Impact	200 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	14 to 26 Ω
Resistance at + 125 °C	max. 70 Ω
Resistance at +200 °C, V_{pulse} = 345 V [1]	min. 20 kΩ
Switch temperature	+ 125 °C
Temperature coefficient	+28%/°C
Dissipation factor	21 mW/°C
Heat capacity	2,3 J/°C
Thermal time constant	110 s
Operating temperature range	
at zero power	−25 to + 175 °C
at maximum voltage	0 to + 80 °C
Voltage dependence at + 175 °C	0,26
Balance voltage, d.c.	100 V
Maximum r.m.s. voltage, with series resistor of 200 Ω	245 V

[1]) Measurement made without internal heating occurring.

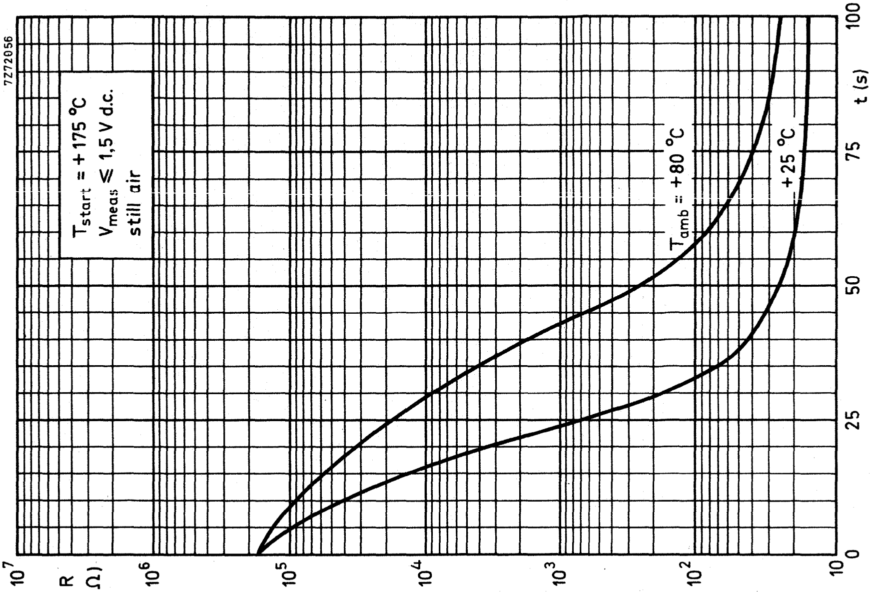


Fig. 3 Typical resistance/time (cooling) characteristics

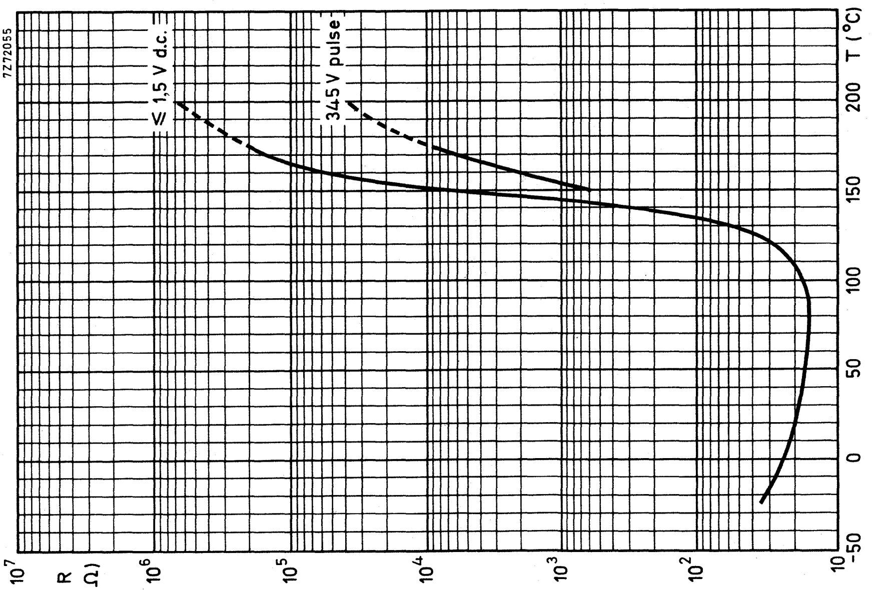


Fig. 2 Typical resistance/temperature characteristics

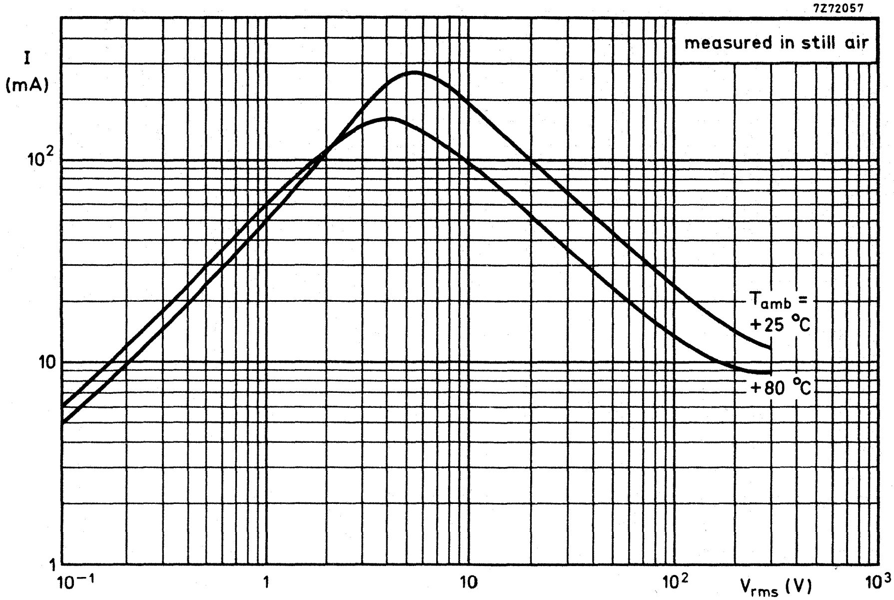


Fig. 4 Typical voltage/current characteristics

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L.	1 %	major defects	– Electrical
A.Q.L.	1,5%	major defects	– Mechanical
A.Q.L.	4 %	minor defects	– Physical

PACKAGING

100 pieces per box (card board).

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 %/°C
Maximum d. c. voltage	16 V
Dissipation factor	27 mW/°C
Operating temperature range at zero power at V_{max}	 −25 to + 155 °C −25 to + 55 °C

APPLICATION

For protection purposes, such like relay coils, loudspeakers, etc.

DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)

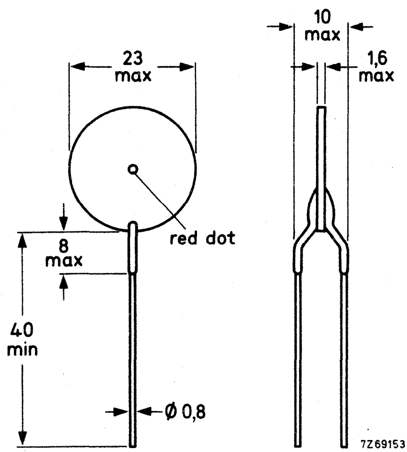


Fig. 1

Marking	The thermistors are marked with a red dot
Weight	2,3 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. 240 °C, max. 4 s

ELECTRICAL DATA

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

Resistance at −25 °C	max. 1,15 Ω 1)
Resistance between +25 and +55 °C	max. 0,6 Ω 1)
Resistance at +150 °C, V_{pulse} = 16 V	min. 40 Ω 2)
Switch temperature	+83 °C *)
Temperature coefficient	10 %/°C *)
Dissipation factor	27 mW/°C 3) *)
Heat capacity	1,2 J/°C 3) *)
Thermal time constant	45 s 3) *)
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	−25 to +55 °C
Maximum d.c. voltage (V_{max})	16 V

*) approximate values

1) d.c. measuring voltage not exceeding 1,5 V to avoid internal heating.

2) measurement made without internal heating occurring.

3) measurements made with specimen in phosphor bronze clips, in still air.

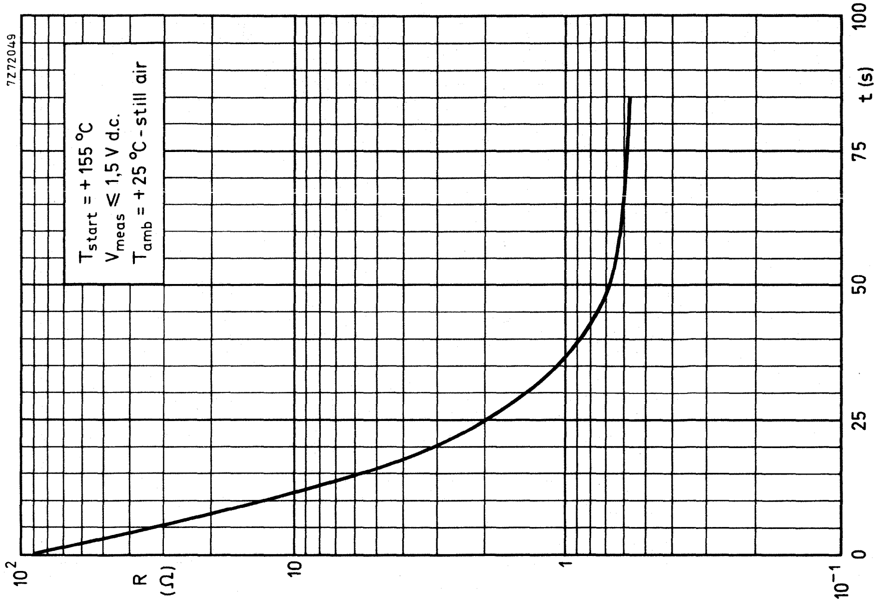


Fig. 3 Typical resistance/time (cooling) characteristic

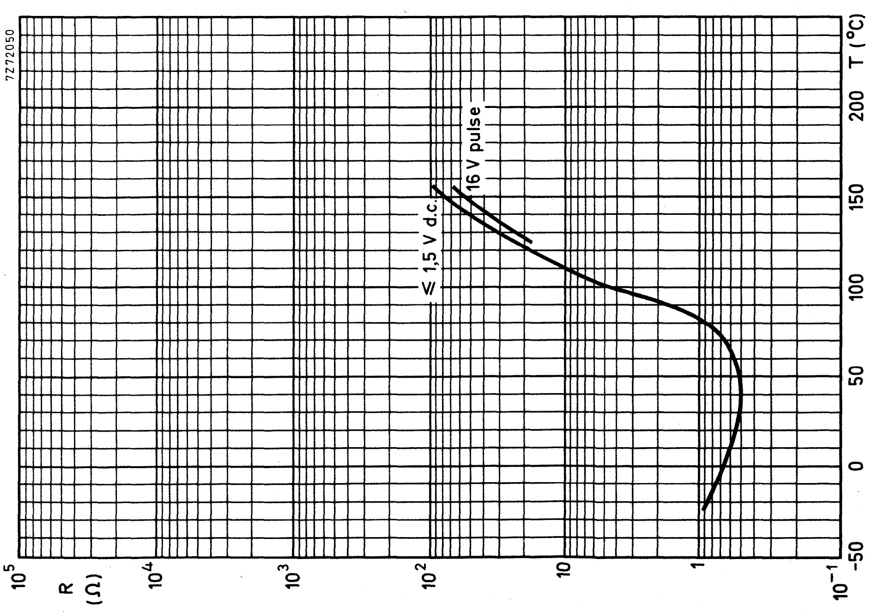


Fig. 2 Typical resistance/temperature characteristics

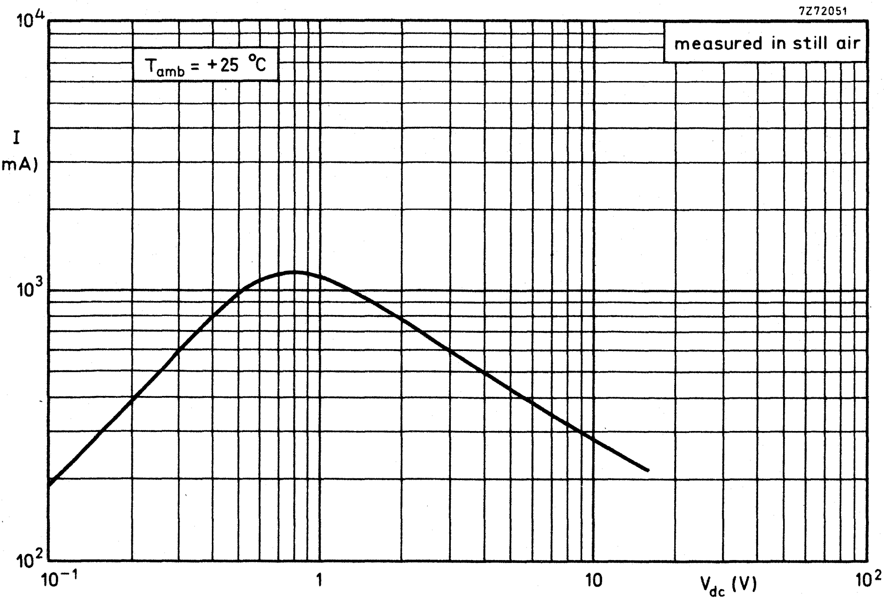


Fig. 4 Typical voltage/current characteristic

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

test	test method	duration	ΔR/R in % at +25 °C	at +150 °C
Cold at −25 °C	A	1000 h	± 30	± 10
Storage at +25 °C	H	1000 h	± 20	± 10
Dry heat + 155 °C	B	1000 h	± 30	± 10
Thermal shock −25 to + 155 °C	Na	5 cycles	± 30	± 10
Damp heat	C	1000 h	± 30	± 10
Dissipation at V = 16 V d.c. and T_{amb} = + 55 °C		168 h	± 30	± 10
Cycle test at V = 16 V d.c. and T_{amb} = −25 °C		100 cycles 1 min on/9 min off	± 30	± 10
Robustness of terminations	U			
Tensile strength 20 N	Ua	10 s	1)	
Bending 10 N	Ub	2 times	1)	
Soldering				
Solderability at 230 °C	par. 3. 2. 3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3. 2. 4	3 to 4 s	± 20	± 10

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after six months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 % major defects – Electrical
A.Q.L. 1,5% major defects – Mechanical
A.Q.L. 4 % minor defects – Physical

PACKAGING

100 pieces per box (cardboard)

PTC THERMISTORS

for level control

QUICK REFERENCE DATA		
	still air −25 °C	fuel oil +50 °C
Current at 12 V d.c.	≤ 39 mA	≥ 45 mA
16 V d c.	≤ 30 mA	≥ 36 mA
18 V d.c.	≤ 27 mA	≥ 33 mA
Switch temperature	160 °C approx.	
Maximum voltage at +75 °C, with a series resistor of 100 Ω	19 V d.c.	
Dissipation factor		
in still air at −25 °C	2 mW/degC approx.	
in still fuel oil at +50 °C	6.25 mW/degC approx.	
Operating temperature range		
at zero power	−55 to +125 °C	
at maximum voltage, in still air	−25 to + 75 °C	
at maximum voltage, in still fuel oil	−25 to + 50 °C	

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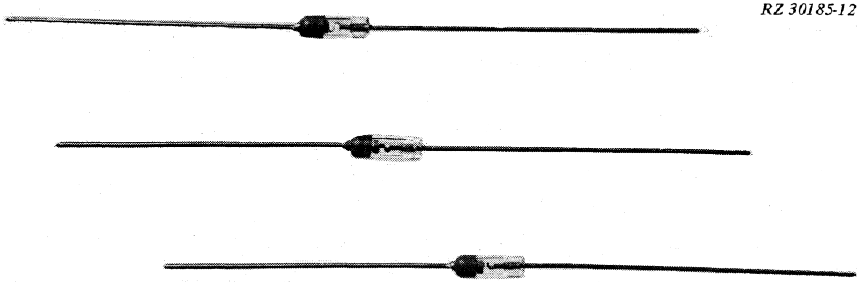


APPLICATION

Intended for level control of fuel oil in oiltanks.

DESCRIPTION

A miniature thermistor element is mounted in a glass envelope model DO7, and provided with two connecting leads.

MECHANICAL DATA

Dimensions in mm

Outlines

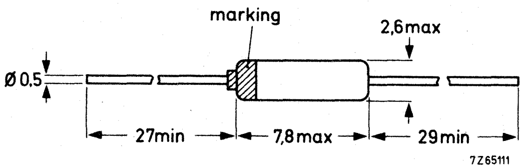


Fig. 1.

Marking

Black colour band *)

Mass

0,2 g approximately

Mounting

Vertically, to be soldered at 25 to 29 mm from the body.
Marked end to be connected to the positive pole.

Robustness of terminations

Tensile strength	10 N
Bending	5 N
Torsion	3 times 360°, in opposite directions

Soldering

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

*) Was red in the past.

ELECTRICAL DATA

Resistance at +25 °C	70 to 250 Ω [1]	
Resistance at +200 °C, V_{pulse} = 18 V	min. 1,8 kΩ [1]	
	still air [2][4]	still fuel oil [2][3][4]
	at $-25^{\ 0}_{-1}$ °C	at $+50^{+1}_{\ 0}$ °C
Current at 12 V d.c. (−2 %)	≤ 39 mA	≥ 45 mA
16 V d.c. (−2 %)	≤ 30 mA	≥ 36 mA
18 V d.c. (−2 %)	≤ 27 mA	≥ 33 mA
Switch temperature	160 °C approx.	
Temperature coefficient	35 %/°C approx.	
Maximum current of static I/V characteristic in still air at $-25^{\ 0}_{-1}$ °C	80 mA [5]	
Maximum voltage at +75 °C, with a series resistor of 100 Ω	19 V d.c.	
Dissipation factor		
in still air, at −25 °C	2 mW/°C approx. [4]	
in still fuel oil, at +50 °C	6,25 mW/°C approx. [3][4]	
Operating temperature range		
at zero power	−55 to +125 °C	
at maximum voltage, in still air	−25 to + 75 °C	
at maximum voltage, in still fuel oil	−25 to + 50 °C [3]	
Maximum temperature of glass envelope	+200 °C	

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

2) Each item fully checked.

3) Brand of fuel oil SHELL S5585.

4) Measurements between phosphor-bronze wires (ϕ 1,3 mm).

5) Even if the voltage corresponding to the maximum static current rises above 6 V, the dissipation will not be more than 480 mW.

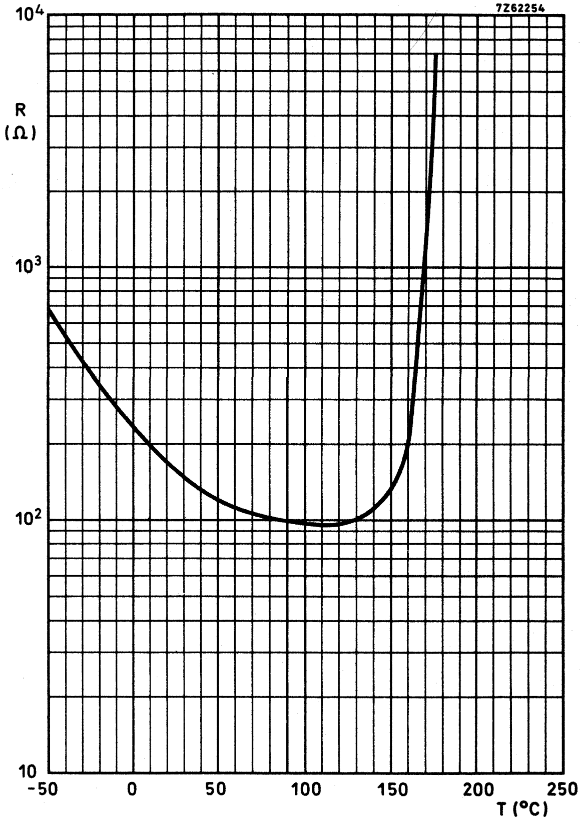


Fig. 2. Typical resistance/temperature characteristic.

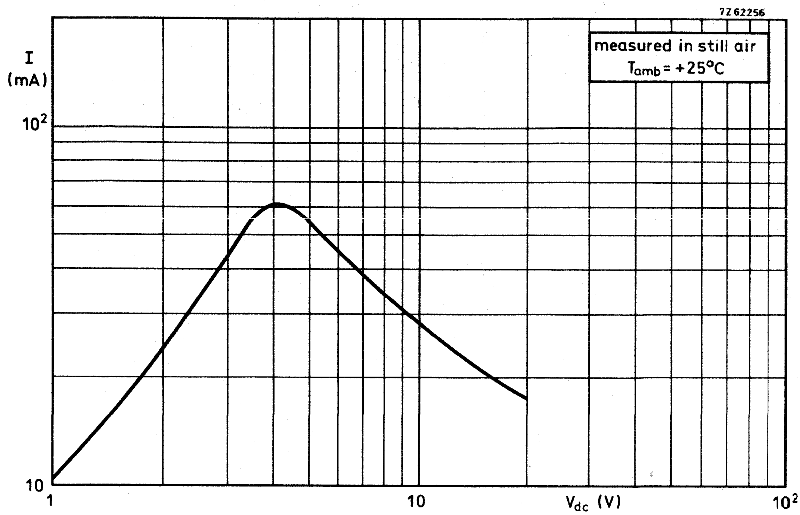


Fig. 3. Typical current/voltage characteristic

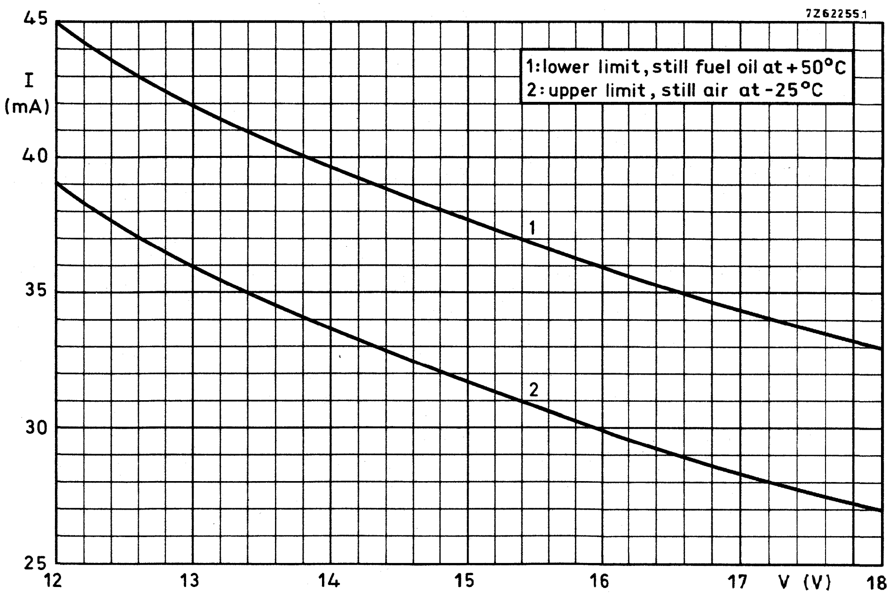


Fig. 4. Current limits versus voltage

TESTS AND REQUIREMENTS

According to IEC 68 recommendation, unless otherwise specified.

test	test method	duration	ΔI/I (%) at + 50 °C	at −25 °C
Cold, −25 °C	A	1000 h	± 3	± 3
Storage at + 25 °C	H	1000 h	± 3	± 3
Dry heat, + 125 °C	B	1000 h	± 5	± 5
Thermal shock, −25 to + 125 °C	Na	5 cycles	± 3	± 3
Damp heat at +40 °C	Ca	1000 h	± 5	± 5
Cycle test at V = 16 V d.c. and T_{amb} = + 25 °C		1000 cycles 1 min on/ 10 min off	± 10	± 10
Combined cycle test	[3]	5000 cycles	± 10	± 10
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	[1]	
Bending 5 N	Ub	2 times	[1]	
Torsion	Uc	3 times	[1]	
Sealing	[4]	24 h	no visible damage	
Soldering	T			
Solderability at 230 ± 10 °C	par. 3.2.3	3 to 4 s	[2]	
Resistance to heat at 230 ± 10 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.

2) Leads must be solderable initially and after six months storage with solder containing resin flux.

3) Test method:
a. Apply voltage of 19 V ± 5% to each item connected in series with a resistor of 100 Ω
b. After 1,5 min immerse in SHELL oil S 5585
c. 0,5 min later, cut off voltage
d. The next 0,5 min the items remain in the fuel oil without voltage applied
e. The items are taken out the fuel oil and are exposed to the air
f. Again 0,5 min later, the whole sequence is repeated.

4) Test method: The thermistors are immersed for 24 h in an alcoholic solution of fluorescein thinned with water under a pressure of 40 N/cm². Then they are submitted for visual inspection under ultraviolet light.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 0.65 %, major defects - Electrical

A.Q.L. 0.65 %, major defects - Mechanical

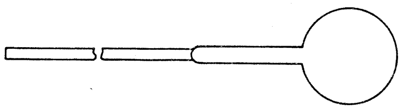
A.Q.L. 4.0 %, minor defects - Physical

PACKAGING

2 x 500 pieces fixed on a plastic band packed per box.

PTC THERMISTORS

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		≥ 4 000 Ω
Switch temperature, T_S		70 to 150 °C
Temperature coefficient		18 to 38 %/°C
Maximum voltage		25 V d.c.
Dissipation factor (version with leads)		5,7 mW/°C
Operating temperature range	at zero power	−25 to (T_S +40) °C
	at maximum voltage	0 to (T_S +25) °C



APPLICATION

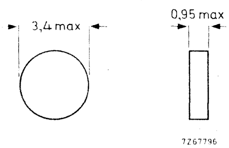
Intended as temperature sensors in domestic appliances, fire alarms, car electronics, etc.

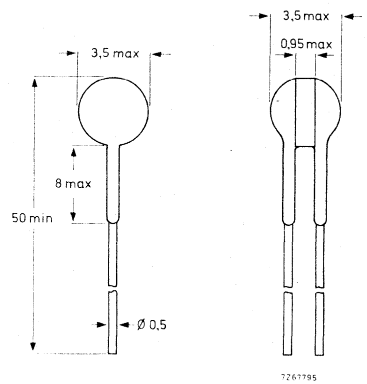
DESCRIPTION

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

MECHANICAL DATA

Dimensions (mm)





version without leads Fig. 1 version with leads

Marking

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

Weight

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

Impact

Free fall	1 m

ELECTRICAL DATA

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

T_S (^oC)	temperature coefficient (%/ ^oC)	balance voltage (V d.c.)	voltage dependence β at(T_S+25)^oC	colour code for version with leads	catalogue number 2322 672 ..... 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) ^oC	30 to 250 Ω [1])
Resistance value at (T_S + 5) ^oC	≤ 550 Ω [1])
Resistance value at (T_S + 15) ^oC	≥ 1330 Ω [1])
Resistance value at (T_S + 25) ^oC, V_{pulse} = 7,5 V	≥ 4000 Ω [2])
Maximum voltage	25 V d.c.
Dissipation factor (version with leads)	5,7 mW/ ^oC
Thermal time constant (version with leads)	9 s
Heat capacity (version with leads)	0,05 J/ ^oC
Operating temperature range	
at zero power	−25 to (T_S + 40) ^oC
at maximum voltage	0 to (T_S + 25) ^oC

[1]) Measuring voltage not exceeding 2,5 V d.c. to avoid internal heating.
[2]) Measurements made without internal heating occurring.

Typical resistance/temperature characteristics

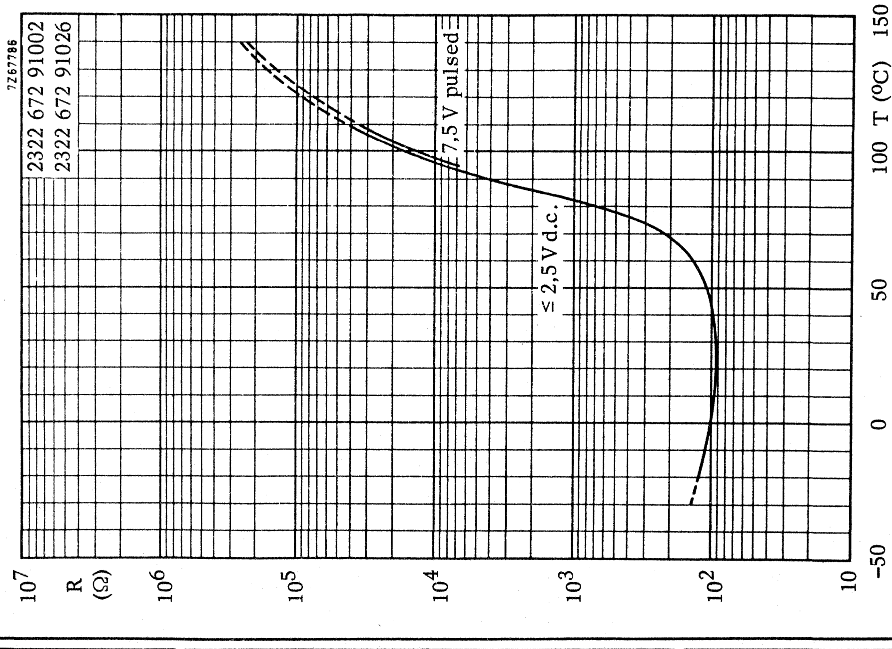


Fig. 2

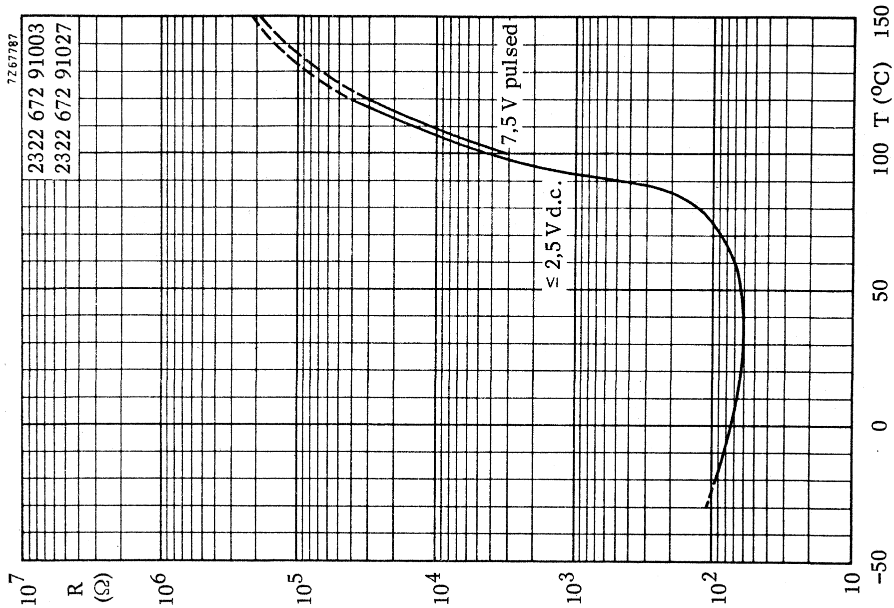


Fig. 3

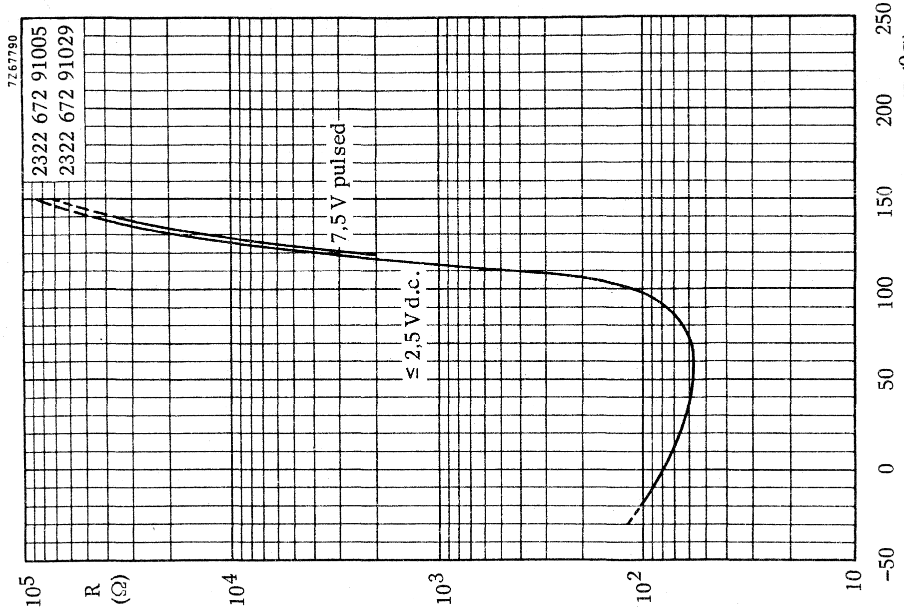

7Z67790
2322 672 91005
2322 672 91029
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 5

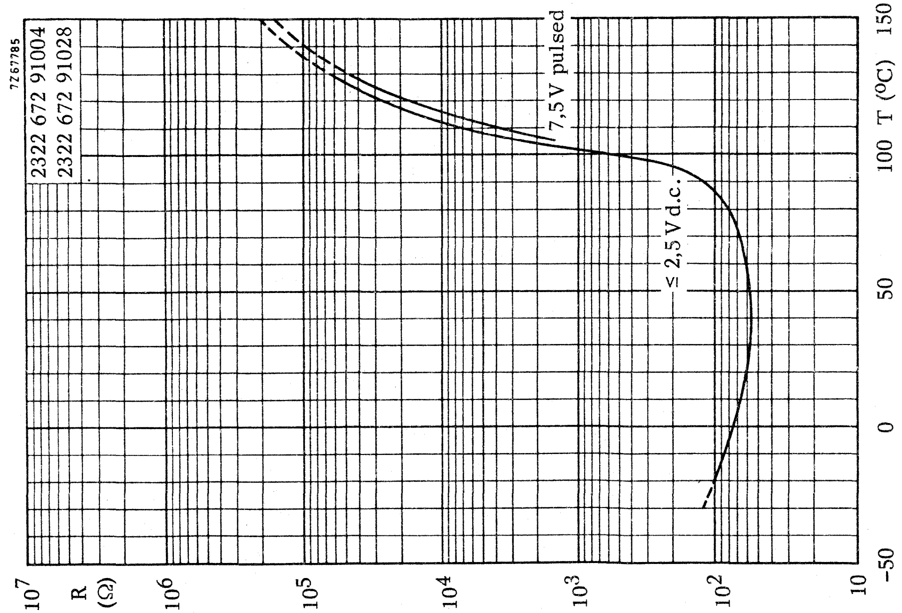

7Z67785
2322 672 91004
2322 672 91028
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^7
10^6
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150

Fig. 4

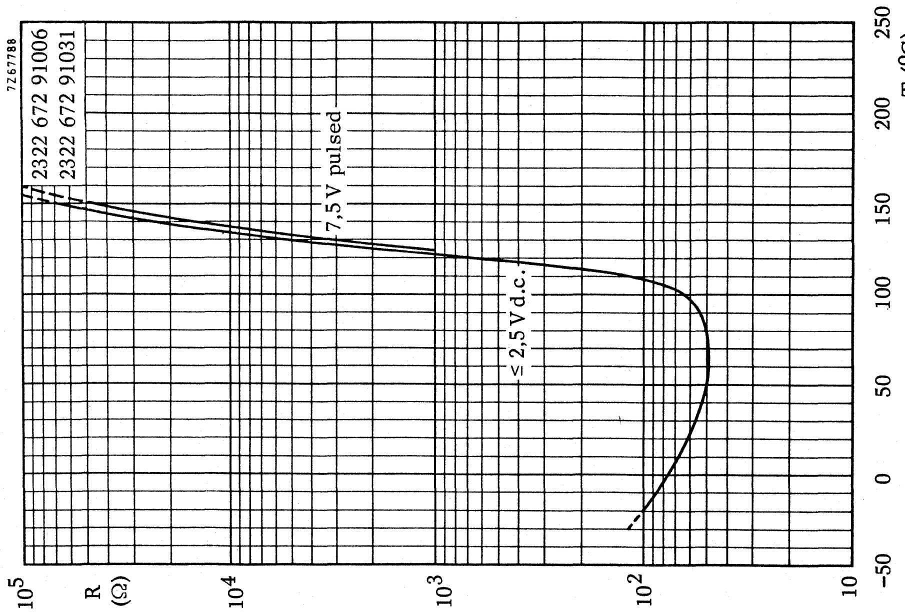

7Z67788
2322 672 91006
2322 672 91031
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 6

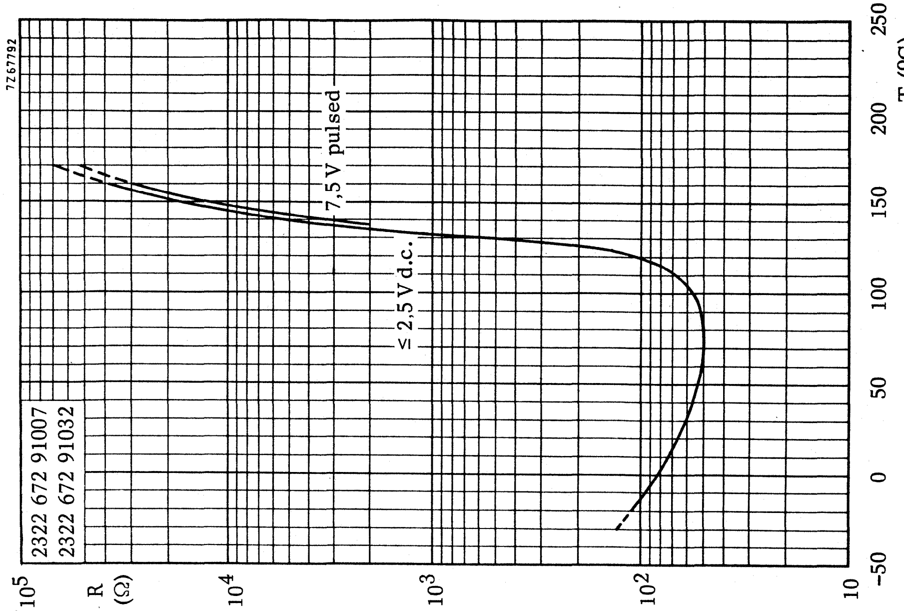

7Z67792
2322 672 91007
2322 672 91032
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 7

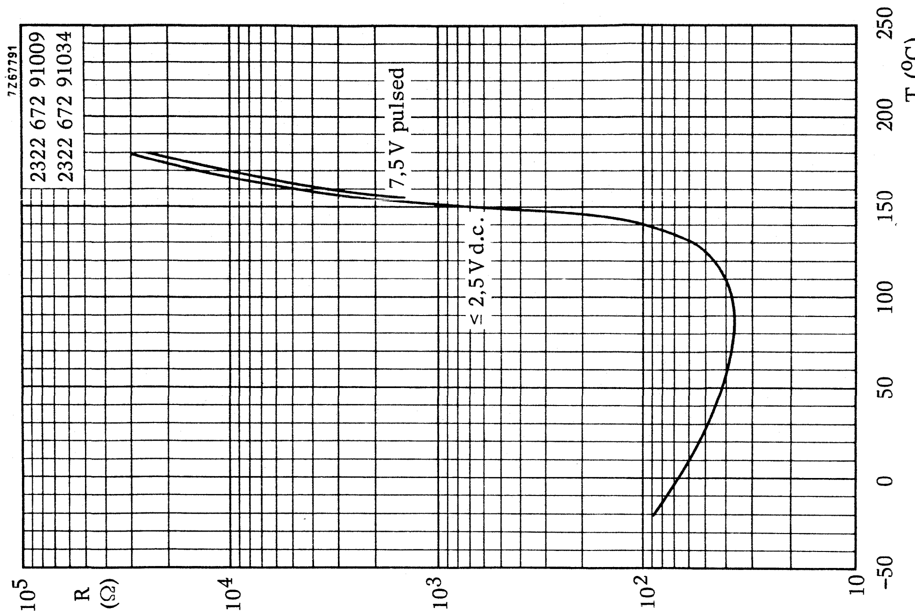

7Z67791
2322 672 91009
2322 672 91034
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 9

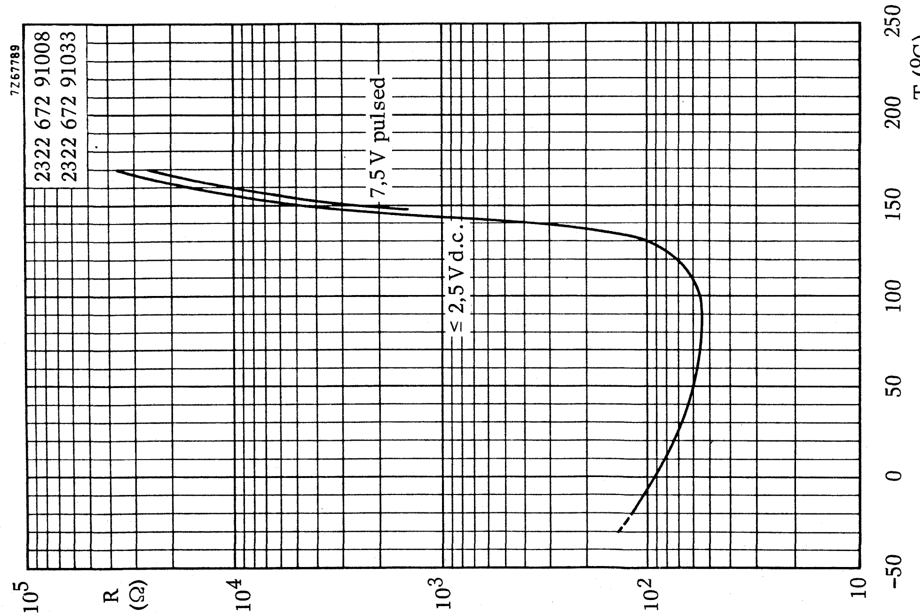

7Z67789
2322 672 91008
2322 672 91033
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 8

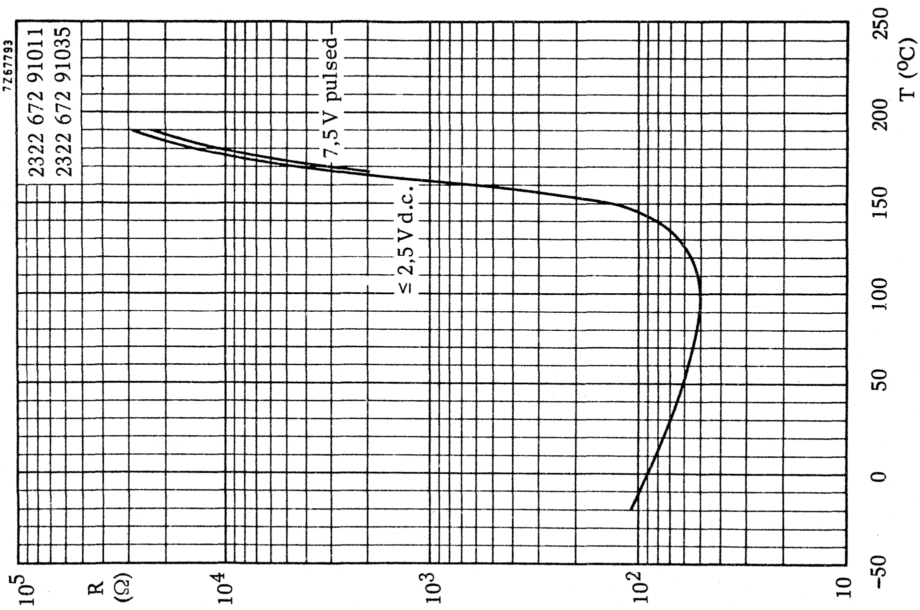


Fig.10

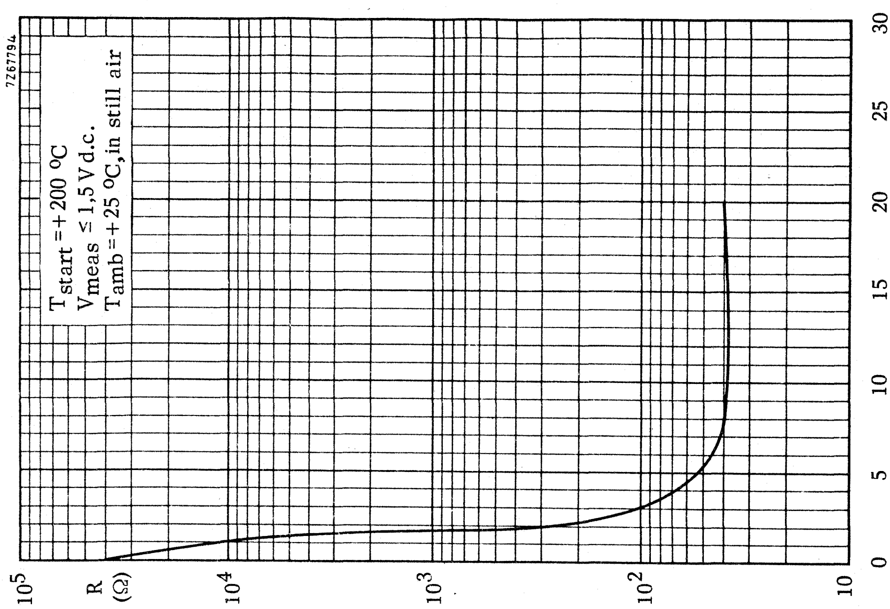


Fig.11. Typical resistance/time (cooling) characteristic

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	ΔR/R in % at +25 °C	ΔR/R in % at T_s+40 °C
both versions				
Cold at −25 °C	A	1000 h	± 5	± 5
Storage at +25 °C	H	1000 h	± 5	± 5
Dry heat at (T_s+40) °C	B	1000 h	± 10	± 10
Thermal shock −25 to (T_s +40) °C	Na	5 cyles	± 10	± 10
Damp heat at +40 °C	C	1000 h	± 5	± 5
Dissipation at 25 V d.c. and T_{amb}= +25 °C		1000 h	± 5	± 5
Impact	E			
Free fall	Ed	2 falls	1)	
version with leads only				
Dissipation in damp heat		336 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	2)	
Bending 5 N	Ub	2 times	2)	
Soldering	T			
Solderability	par. 3. 2. 3	3 to 4 s	3)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2

1) No visual defects will be stated.
2) Leads should neither come loose nor break.
3) Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D

A.Q.L. 1 %, major defects − Electrical
A.Q.L. 1,5 %, major defects − Mechanical
A.Q.L. 4 %, minor defects − Physical

PACKAGING

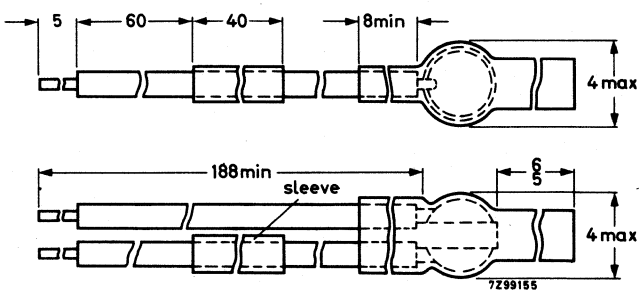
Version with leads	500 pieces per box (cardboard)
Version without leads	2000 pieces per box (cardboard)

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
Switch temperature	see table
Temperature coefficient	see table
Max. voltage	15 V_{dc}
Dissipation factor	7 mW/deg C approx.
Operating temperature range at zero power at V_{max}	 −20 to T_{ref} +30 °C −20 to T_{ref} +15 °C

DIMENSIONS in mm



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

This type has a positive temperature coefficient. It consists of a disc provided with two tinned copper "Litze" wires with a cross-section not greater than 7/.0076 inch (0.194 mm) and insulated with PTFE material complying with the requirements of the ministry of aviation specification EL 1930.

MECHANICAL DATA

See outline drawing on previous page.

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

Weight — 1.6 g approximately

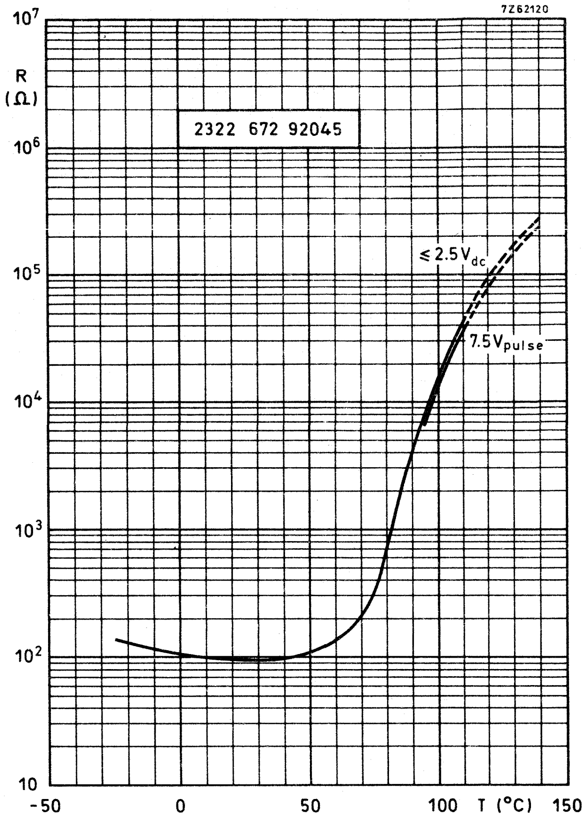
Mounting — In motor windings; connections to be soldered or clamped.

ELECTRICAL DATA

Table

T_{ref} 1) (°C)	T_s (°C)	temperature coefficient (%/ deg C)	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

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/degC approx. 4)
Heat capacity	0.1 J/degC approx. 4)
Thermal time constant	14 s approx. 4)
Response time 5)	≤8 s
Operating temperature range	
at zero power	−20 to +T_{ref} +30 °C
at V_{max}	−20 to +T_{ref} +15 °C
Maximum voltage	15 V_{dc}
Dielectric withstanding voltage between terminals and lead insulation	≥2500 V_{rms}
Insulation resistance between terminals and lead insulation	≥100 MΩ



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_{dc} 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)

Typical resistance/temperature characteristics of the different types

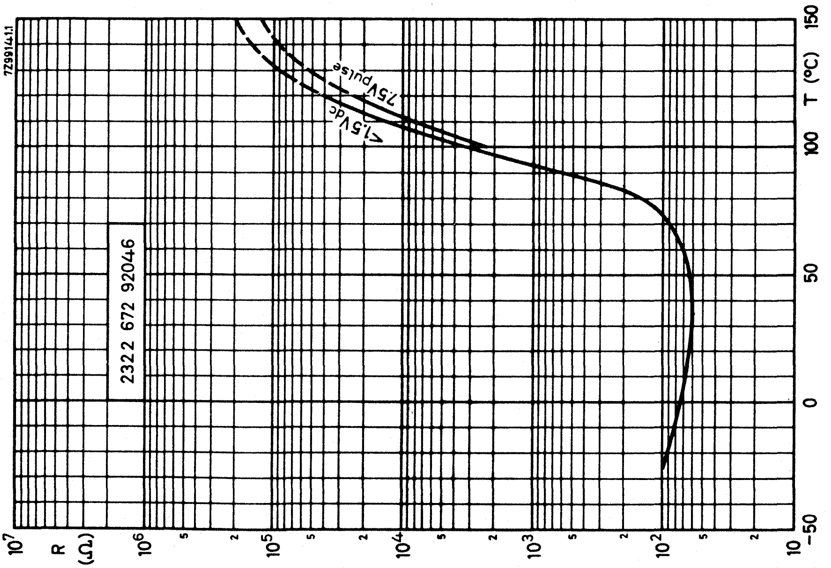


Fig.2

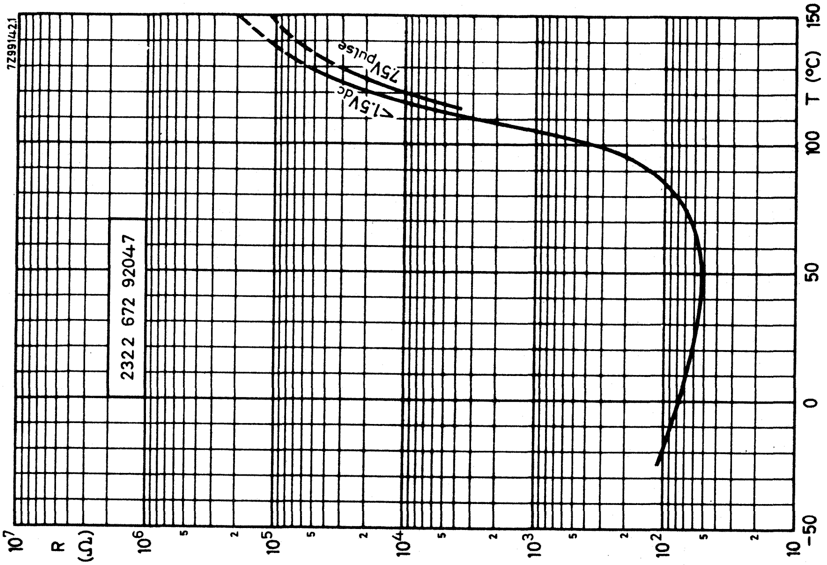


Fig.3

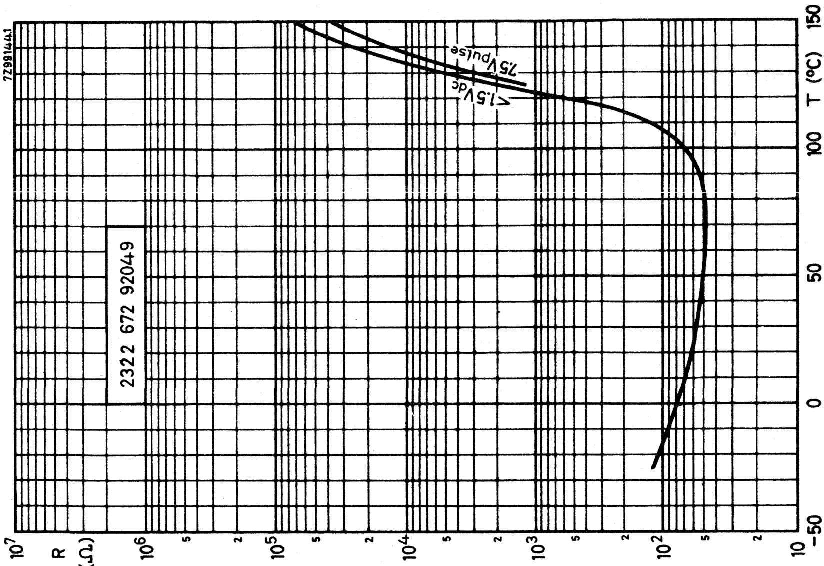

7Z99144.1
2322 672 92049
R (Ω)
T (°C)
<1.5 Vdc
75 Vpulse

Fig. 5

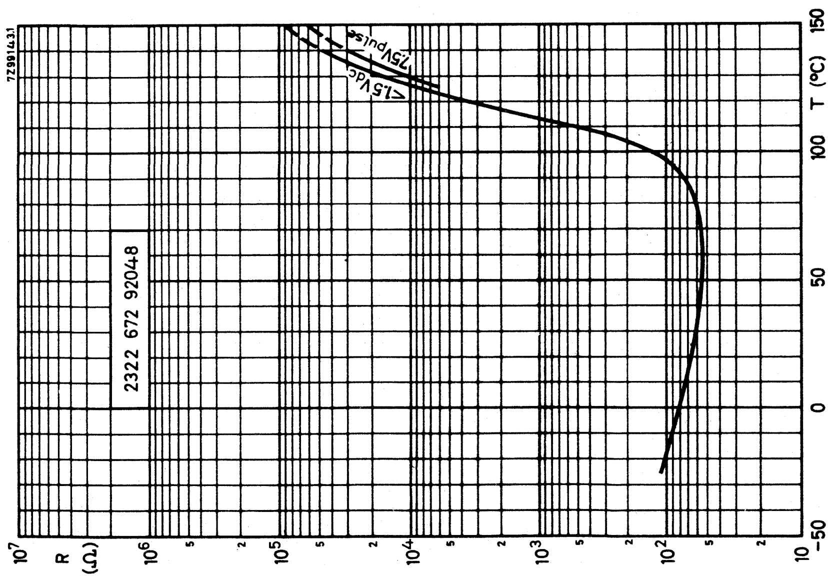
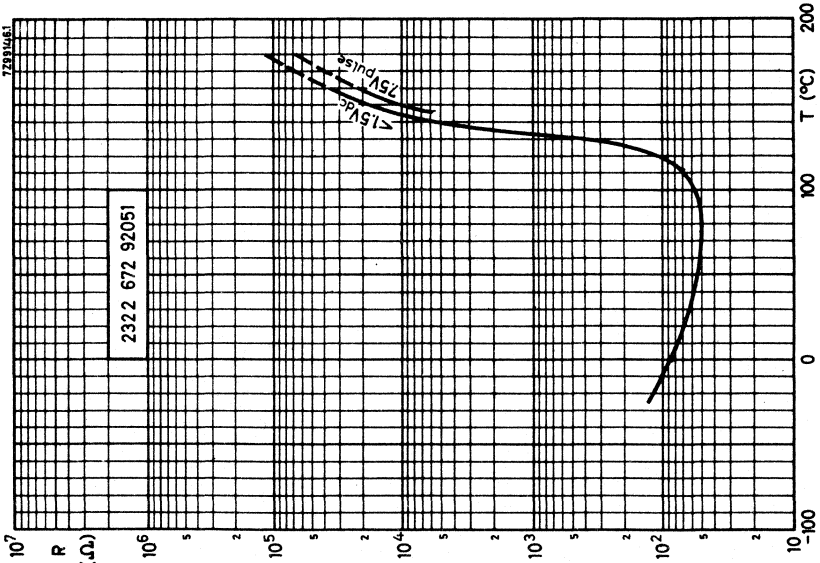
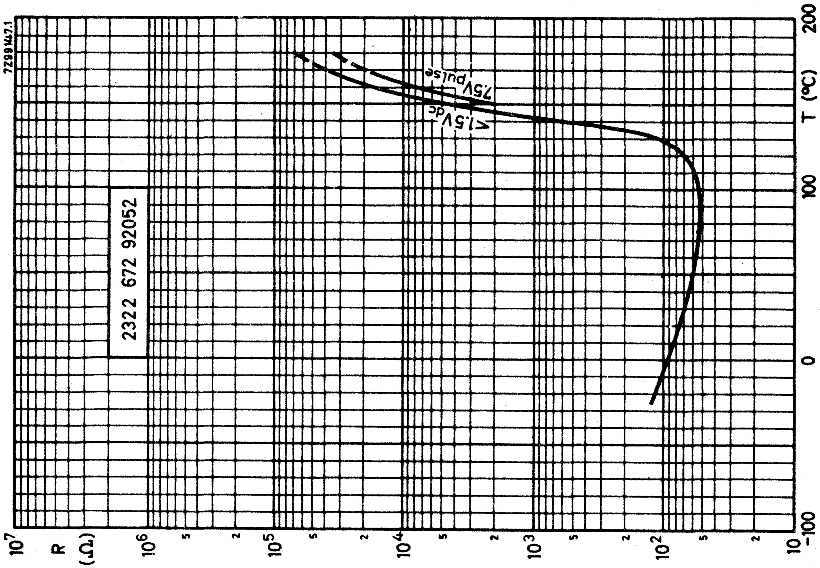

7Z99143.1
2322 672 92048
R (Ω)
T (°C)
<1.5 Vdc
75 Vpulse

Fig. 4



7Z99146.1
2322 672 92051
75V pulse
<1.5Vdc
R (Ω)
T (°C)

Fig. 6



7Z99147.1
2322 672 92052
75V pulse
<1.5Vdc
R (Ω)
T (°C)

Fig. 7

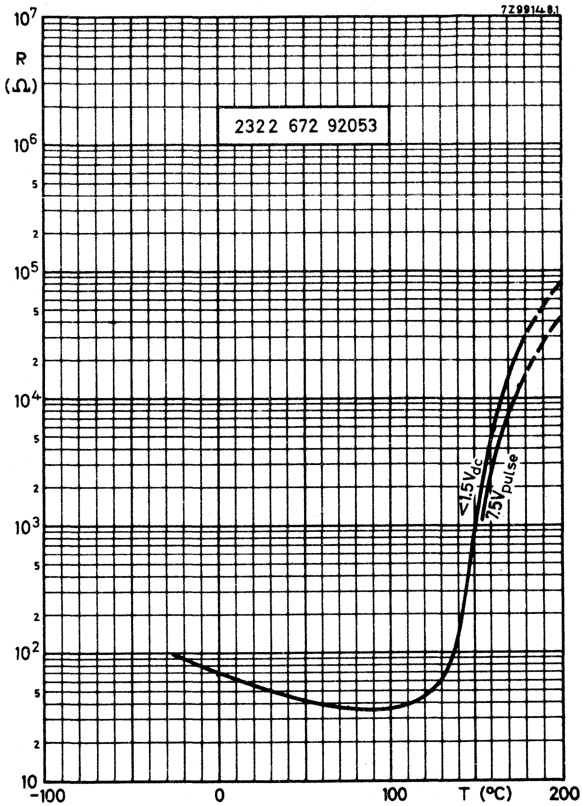

7Z99148.1
R
(Ω)
2322 672 92053
10^7
10^6
10^5
10^4
10^3
10^2
10
5
2
<1.5Vdc
7.5Vpulse
−100
0
100
T (°C)
200

Fig.8

Typical voltage/current characteristics

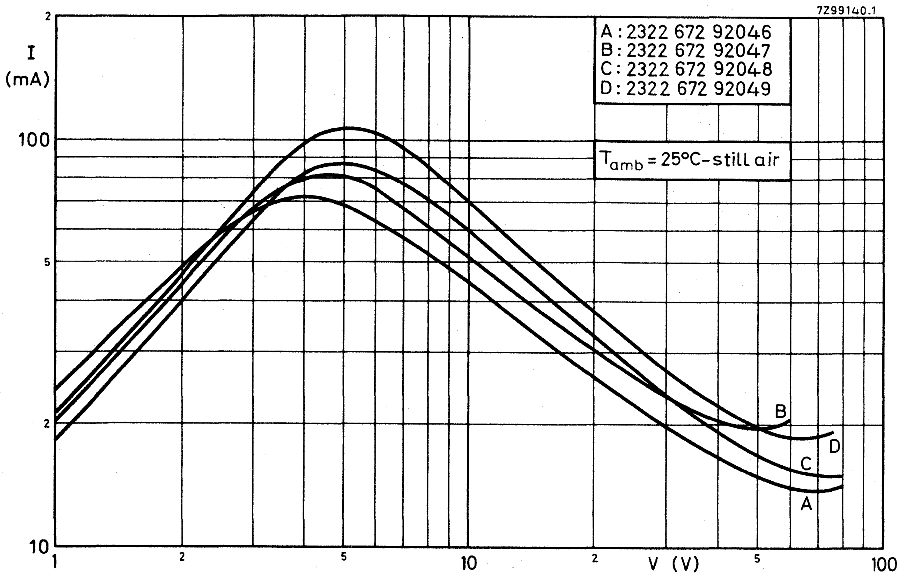


Fig. 9

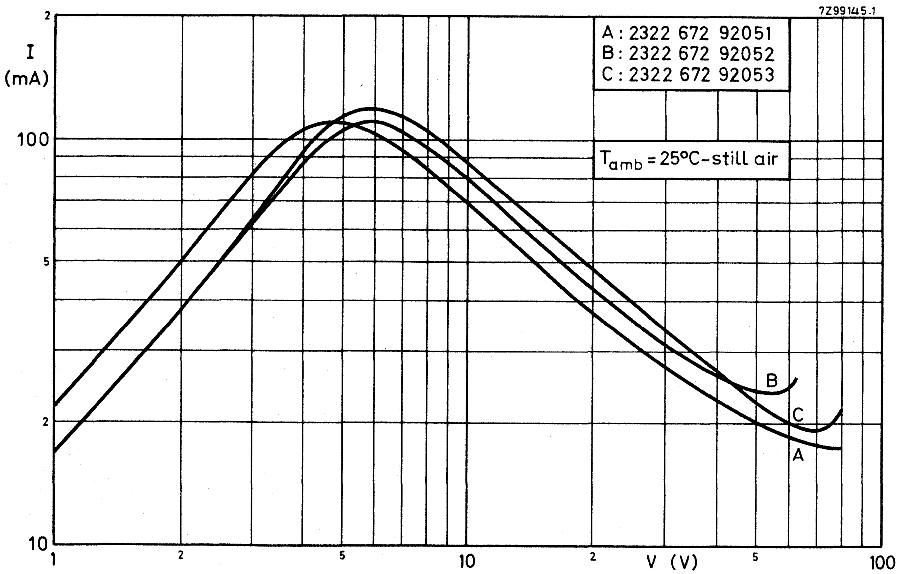


Fig. 10

TESTS AND REQUIREMENTS

According to I.E.C. 68, unless otherwise specified.

Test	test method	duration	ΔR/R in % at 25 °C	ΔR/R in % at T_{ref} +30 °C
Cold at −25 °C	A	1000 h	± 5	± 5
Storage at +25 °C	H	1000 h	± 5	± 5
Dry heat at T_{ref} +25 °C	B	1000 h	± 10	± 10
Dry heat at 200 °C	–	2 cycles 3)	± 10	± 10
Thermal shock −25 to T_{ref} +30 °C	Na	5 cycles	± 10	± 10
Max. peak temperature T_{ref} +90 °C	–	6 cycles 4)	± 20	± 20
Damp heat	C	1000 h	± 5	± 5
Dissipation at V = 15 V_{rms} and T_{amb} = +25 °C		1000 h	± 5	± 5
Robustness of terminations	U			
Tensile strength 10 N	Ua	10 s	1)	
Bending 5 N	Ub	2 times	1)	
Soldering	T			
Solderability at 230 °C	par. 3.2.3	3 to 4 s	2)	
Resistance to heat at 230 °C	par. 3.2.4	3 to 4 s	± 2	± 2

1) Leads should neither come loose nor break.
2) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
3) One cycle = 16 h at +200 °C, 1 h at +25 °C.
4) One cycle = 1 h at T_{ref} +90 °C, 168 h at T_{ref}, in silicon oil free of oxidation.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1.5 %, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical.

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 approximately
Temperature coefficient	min. 10%/°C
Maximum voltage (d.c.)	33 V
Operating temperature range at zero power at maximum voltage	 −25 to +155 °C +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 Dimensions in mm

Outlines

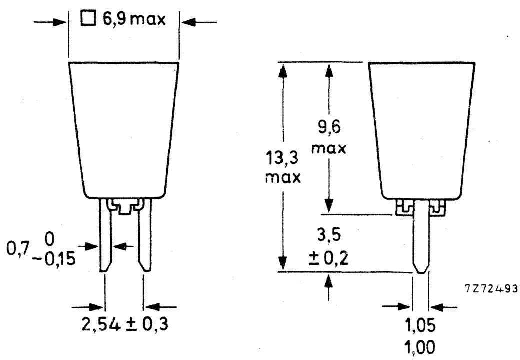


Fig. 1

Marking

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

Weight	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

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

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. 15000 Ω
Switch temperature	+97 °C
Temperature coefficient	min. +10%/°C
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

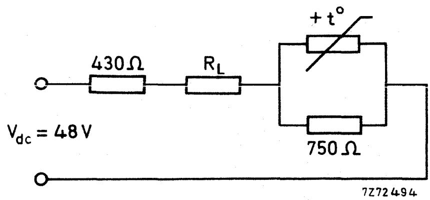
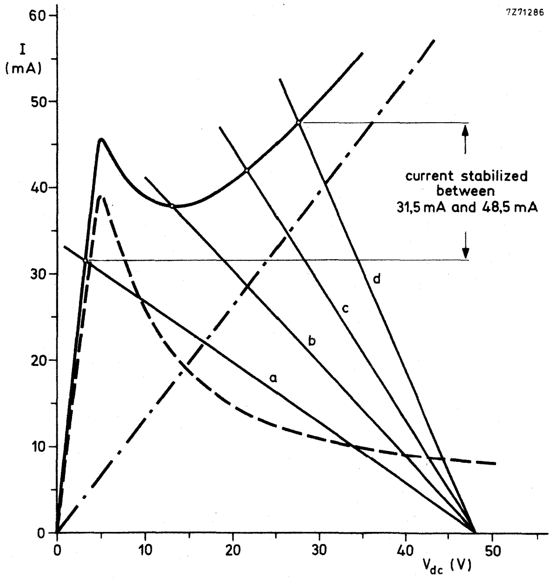


Fig. 2 Line resistance (R_L) compensation

Initial current at +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.

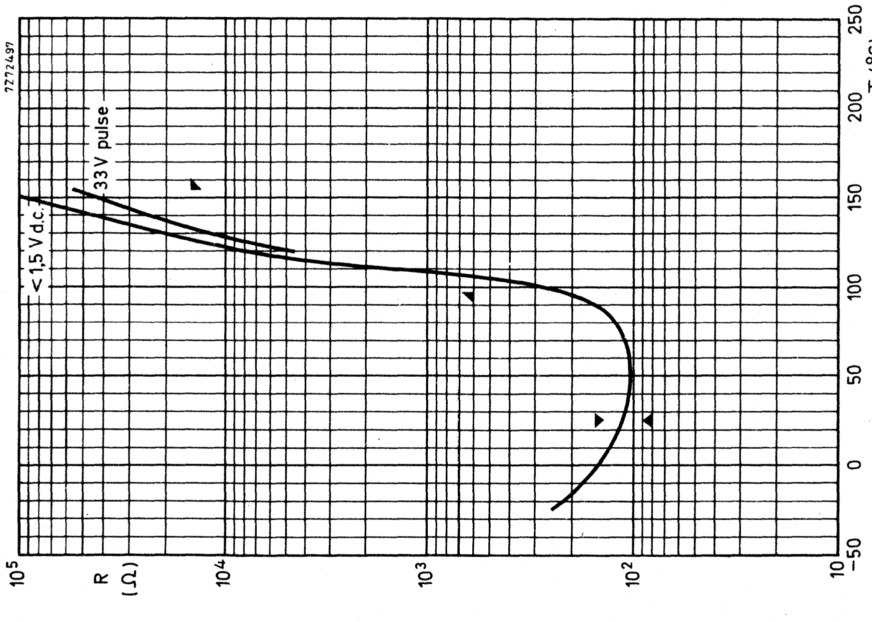


Fig. 4 Typical resistance/temperature characteristics

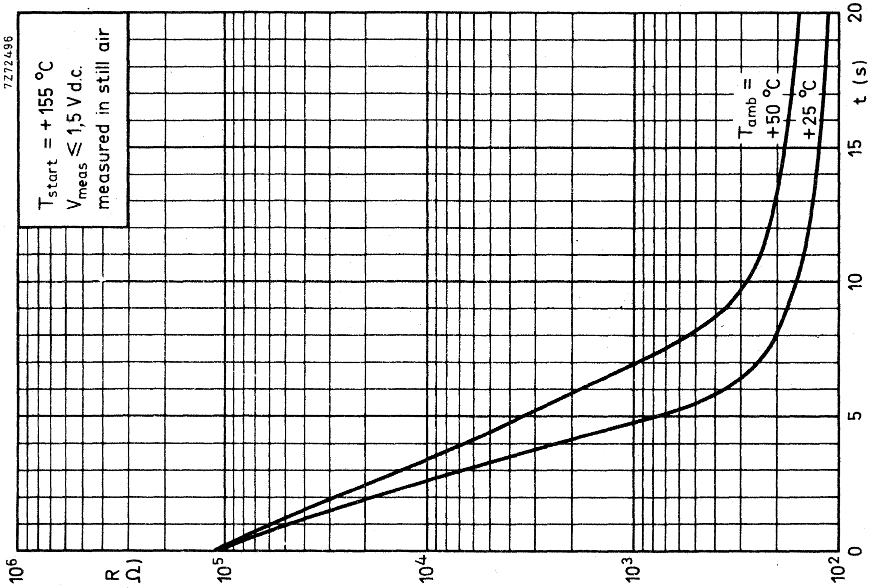


Fig. 5 Typical resistance/time (cooling) characteristics

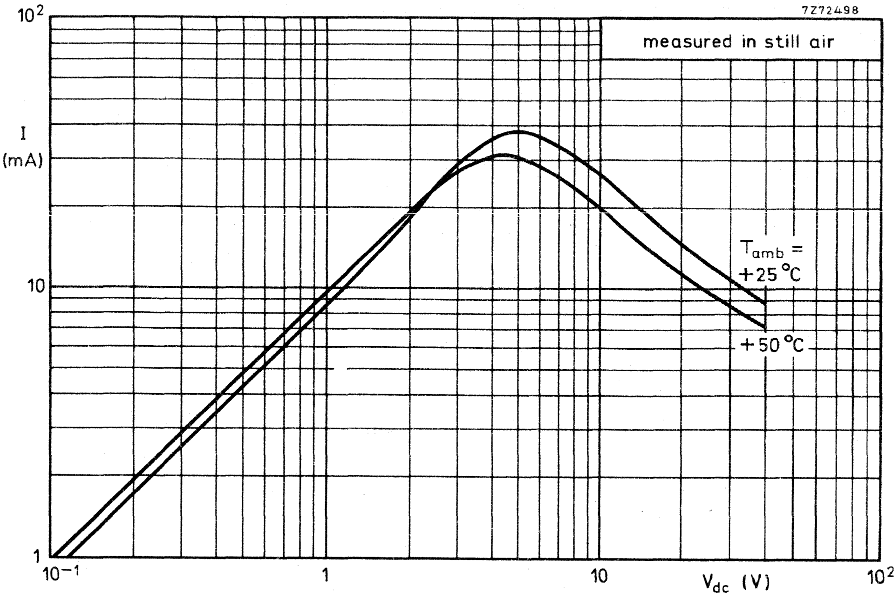


Fig. 6 Typical voltage/current characteristics

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

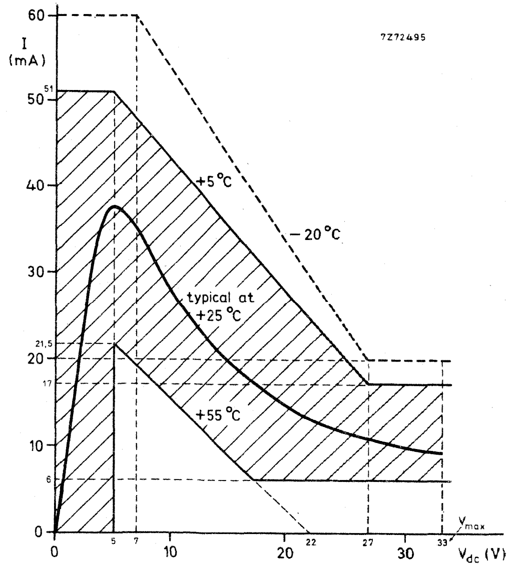


Fig. 7
Area of current/voltage characteristics

TESTS AND REQUIREMENTS

According to IEC recommendations unless otherwise specified.

test	test method	duration	ΔR/R (%) at +25 °C	ΔR/R (%) at +155 °C
Cold at −25 °C	A	1000 h	± 7,5	± 12
Storage at +25 °C	H	1000 h	± 5	± 12
Dry heat at +155 °C	B	1000 h	± 10	± 12
Thermal shock −25 to +155 °C	Na	5 cycles	± 7,5	± 12
Damp heat at +40 °C	C	1000 h	± 10	± 12
Dissipation in damp heat		336 h	± 10	± 12
Dissipation at V_{dc} = 33 V and T_{amb} = +55 °C		1000 h	± 10	± 12
Cycle test at V_{dc} = 33 V and T_{amb} = +5 °C	1)	2000 cycles	± 10	± 12
Cycle test at V_{dc} = 33 V and T_{amb} = +25 °C	1)	40 000 cycles	± 7,5	± 12
Combined cycle test			± 10	± 12
Robustness of terminations	U			
Tensile strength	Ua	10 s	± 3 2)	± 3
Soldering	T			
Solderability	par. 3.2.3	3 to 4 s	3)	
Resistance to heat	Tb	10 ± 1 s	± 2	± 2
Vibration	F		± 3	
Impact				
Free fall	Ed	2 falls	4)	

1) Cycle: 15 s on; 45 s off.
2) Leads should neither come loose nor break.
3) Leads must be solderable initially and after 6 months storage with solder containing resin flux.
4) No visual defects.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

A.Q.L. 1 %, major defects - Electrical
A.Q.L. 1,5%, major defects - Mechanical
A.Q.L. 4 %, minor defects - Physical

PACKAGING

5000 pieces per cardboard box (containing 10 foam plastic trays).

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. 8 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

Dimensions in mm

Outlines

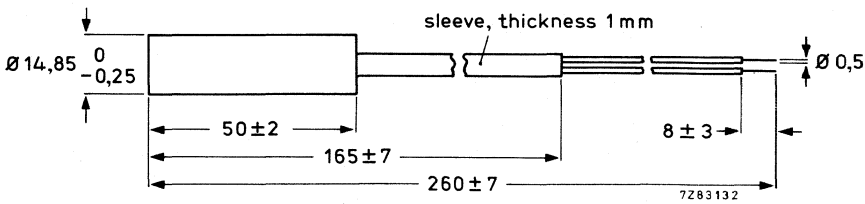


Fig. 1.

Marking

PHILIPS, 2322 680 90011, 100-265 V, 17 W and batch no. on the body.

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	1830 mm

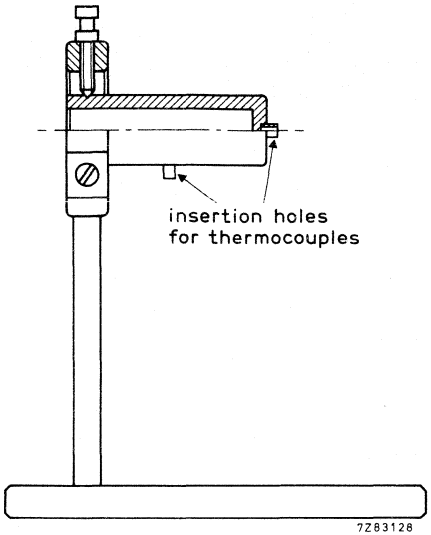
ELECTRICAL DATA

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	500 W
Operating power at 220 V, after 20 min*	17 W ± 20%
Time to reach + 130 °C at 220 V*	max. 8 min
Temperature on standard test mounting after 20 min	
at 120 V	min. + 145 °C
at 220 V	+ 161 ± 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

* Measured when mounted in standard test mounting of Fig. 2.

** The heating element contains 2 silicone rubber tubes. The inner dark grey tube has a min. dielectric withstanding voltage of 1,5 kV, the outer light grey 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.



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 20900	iron-constantan
4304 101 20910	copper-constantan
4304 101 20920	nickelchrome-nickel

Thermocouples conform to DIN.

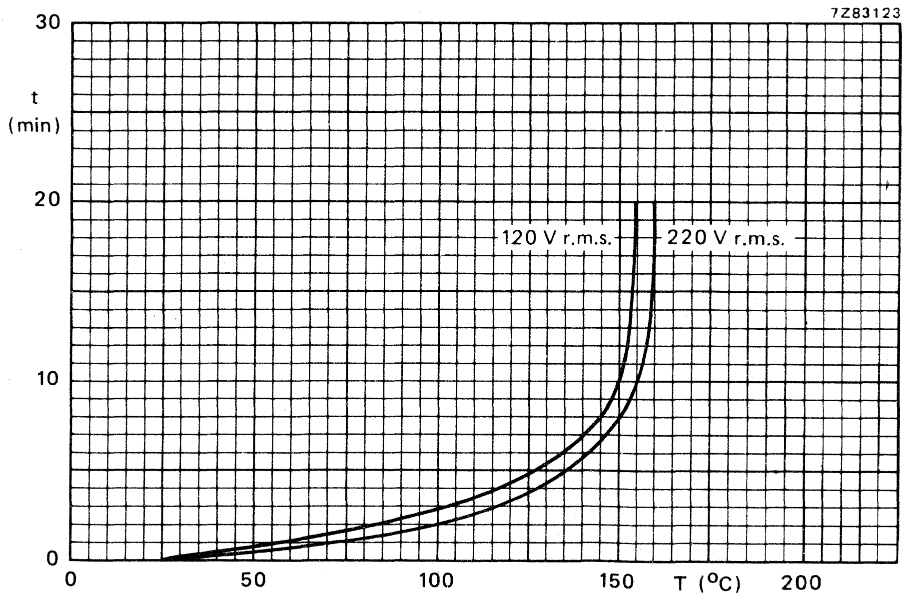


Fig. 3 Typical temperature versus time characteristics.
Measured in standard test mounting. $T_{amb} = +23$ °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at −25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock −25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric with-standing voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 240 V and T_{amb} = 25 °C, elements mounted within tube assembly		200 h	
Cycle test at V_{rms} = 240 V and T_{amb} = 25 °C, elements mounted within tube assembly		1200 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		
Free fall	Ed	2 falls	
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	
Torsion	Uc	3 times	
Solderability	T par. 3.2.3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at −25 °C/ 16 h at + 60 °C.
2. Cycle: 10 min on/ 40 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

500 pieces per cardboard box.

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

Dimensions in mm

Outlines

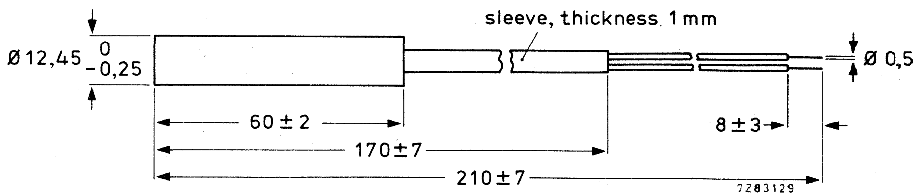


Fig. 1.

Marking

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

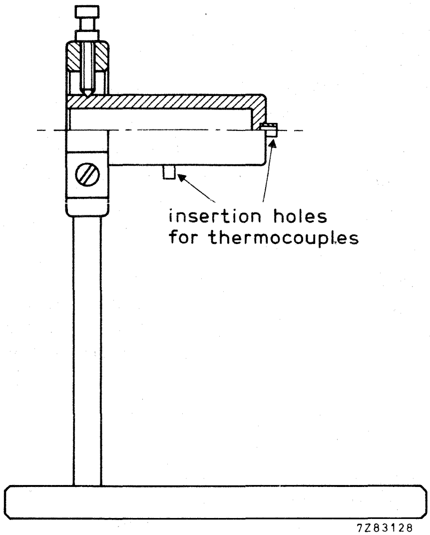
ELECTRICAL DATA

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

* Measured when mounted in standard test mounting of Fig. 2.

** The heating element contains 2 silicone rubber tubes. The inner dark grey tube has a min. dielectric withstanding voltage of 1,5 kV, the outer light grey 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.



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 20950	iron-constantan
4304 101 20960	copper-constantan
4304 101 20970	nickelchrome-nickel

Thermocouples conform to DIN.

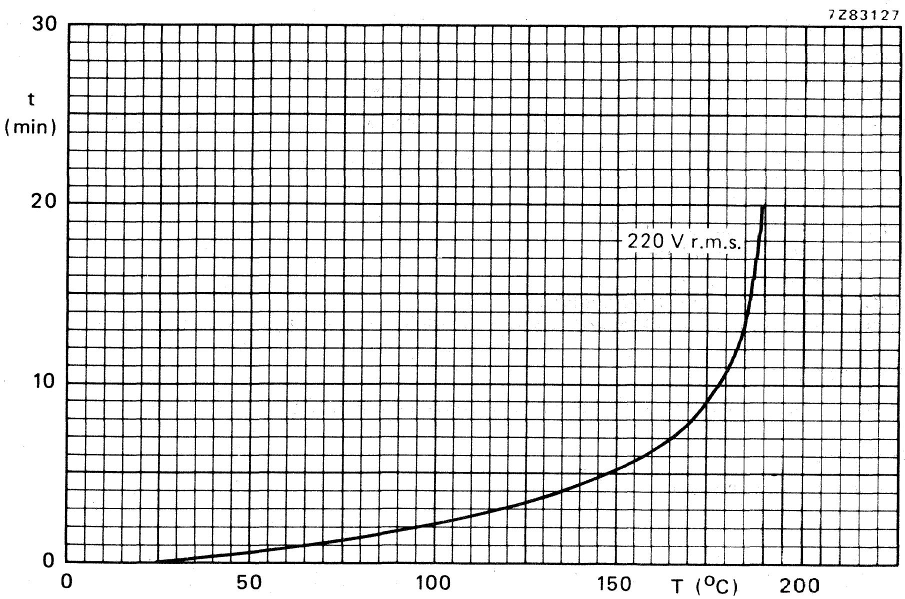


Fig. 3 Typical temperature versus time characteristics.
Measured in standard test mounting. T_{amb} = + 23 °C.

TESTS AND REQUIREMENTS

According to IEC68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at –25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock –25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric withstanding voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 240 V and T_{amb} = 25 °C, elements mounted within tube assembly		450 h	
Cycle test at V_{rms} = 240 V and T_{amb} = 25 °C, elements mounted within tube assembly		1350 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		(note 3)
Free fall	Ed	2 falls	(note 3)
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	(note 4)
Torsion	Uc	3 times	
Solderability	T par. 3.2.3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at –25 °C/ 16 h at + 60 °C.
2. Cycle: 10 min on/ 40 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

500 pieces per cardboard box.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V after 20 min	17 W ± 20%
Time to reach + 130 °C at 120 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

Heating element composed of a PTC thermistor moulded in a silicone rubber tube and two insulated solid copper wires.

MECHANICAL DATA

Dimensions in mm

Outlines

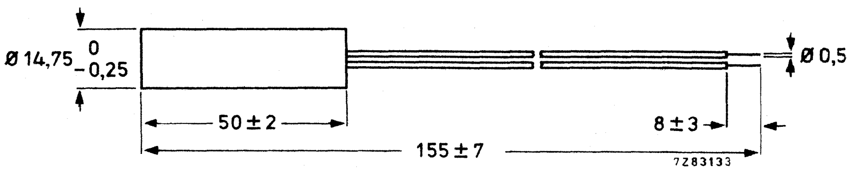


Fig. 1.

Marking

PHILIPS, 2322 680 90058, 100-240 V, 17 W, batch no. and UL recognition mark.

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^{o}
Soldering	
Solderability	max. 240 ^{o}C, max. 6 s
Impact	
Free fall	1830 mm

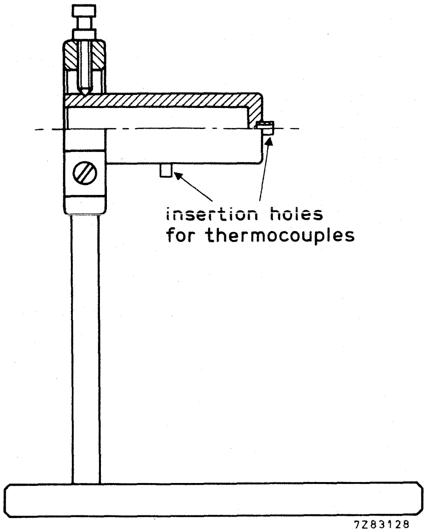
ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 ^{o}C.

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V, after 20 min*	17 W ± 20%
Time to reach + 130 ^{o}C at 120 V*	max. 7 min
Temperature on standard test mounting after 20 min	
at 120 V	+ 164 ± 8 ^{o}C
at 240 V	max. + 185 ^{o}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 ^{o}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 ^{o}C, measured inside test chamber	min. 10 MΩ
Ambient temperature range at zero power and at maximum voltage	−25 to + 60 ^{o}C

* Measured when mounted in standard test mounting of Fig. 2.

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



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 20900	iron-constantan
4304 101 20910	copper-constantan
4304 101 20920	nickelchrome-nickel

Thermocouples conform to DIN.

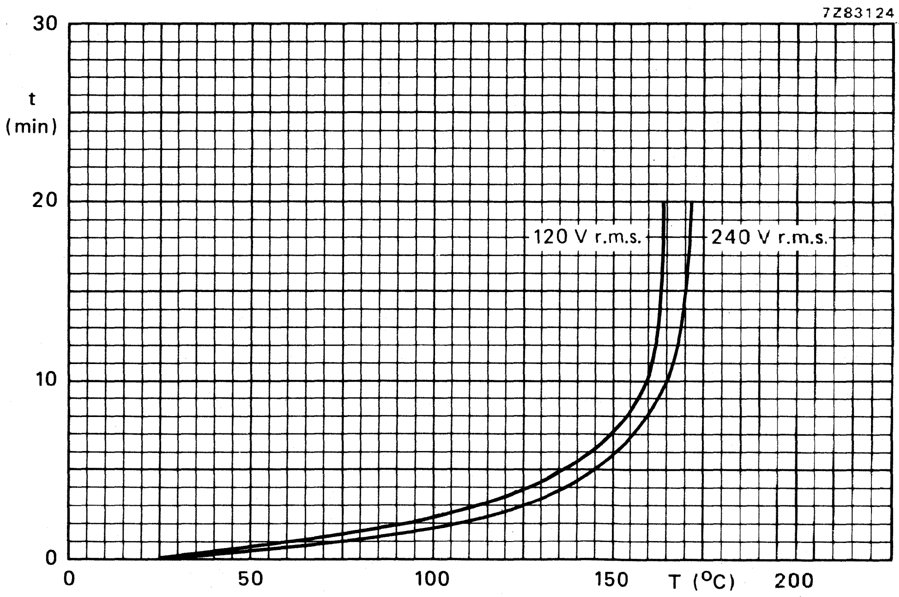


Fig. 3 Typical temperature versus time characteristics.
Measured in standard test mounting. T_{amb} = + 23 °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at −25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock −25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric withstanding voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly.		450 h	
Cycle test at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly		1350 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		(note 3)
Free fall	Ed	2 falls	(note 3)
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	(note 4)
Torsion	Uc	3 times	
Solderability	T par. 3.2.3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at −25 °C/ 16 h at + 60 °C.
2. Cycle: 20 min on/ 30 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

500 pieces per cardboard box.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 265 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V after 20 min	17 W ± 20%
Time to reach + 130 °C at 120 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

Dimensions in mm

Outlines

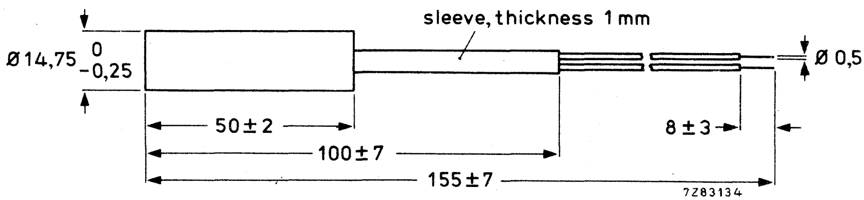


Fig. 1.

Marking

PHILIPS, 2322 680 90059, 100-265 V, 17 W and batch no. on the body.

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	1830 mm

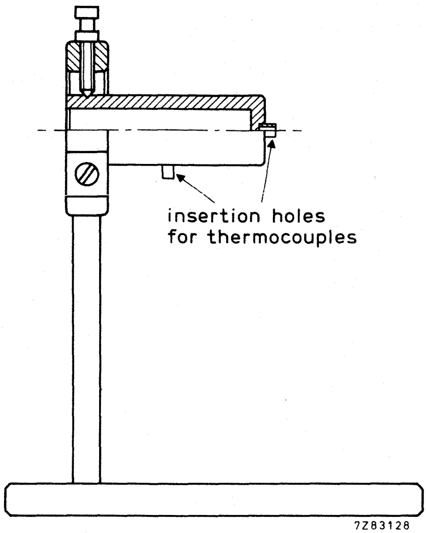
ELECTRICAL DATA

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 120 V	200 W
Operating power at 120 V, after 20 min*	17 W ± 20%
Time to reach + 130 °C at 120 V*	max. 7 min
Temperature on standard test mounting after 20 min	
at 120 V	+ 158 ± 8 °C
at 240 V	max. 180 °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

* Measured when mounted in standard test mounting of Fig. 2.

** The heating element contains 2 silicone rubber tubes. The inner dark grey tube has a min. dielectric withstanding voltage of 1,5 kV, the outer light grey 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.



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 20900	iron-constantan
4304 101 20910	copper-constantan
4304 101 20920	nickelchrome-nickel

Thermocouples conform to DIN.

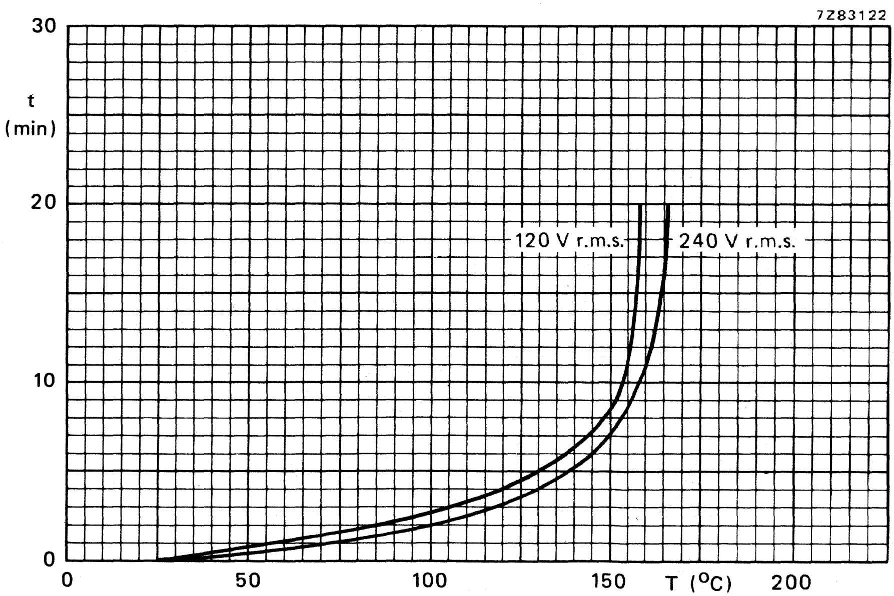


Fig. 3 Typical termperature versus time characteristics.
Measured in standard test mounting. T_{amb} = + 23 °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at −25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock −25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric with-standing voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 265 V and T_{amb} = 25 °C, elements mounted within tube assembly		450 h	
Cycle test at V_{rms} = 265 V and T_{amb} = 25 °C, elements mounted within tube assembly		1350 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		
Free fall	Ed	2 falls	
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	
Torsion	Uc	3 times	
Solderability	T par. 3.2.3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at −25 °C/ 16 h at + 60 °C.
2. Cycle: 20 min on/ 30 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

500 pieces per cardboard box.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V after 20 min	17 W ± 20%
Time to reach + 130 °C at 120 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

Heating element composed of a PTC thermistor moulded in a silicone rubber tube and two insulated solid copper wires.

MECHANICAL DATA

Dimensions in mm

Outlines

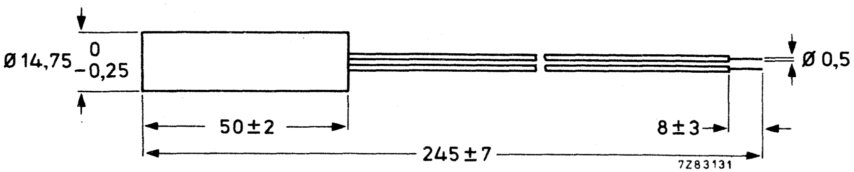


Fig. 1.

Marking

PHILIPS, 2322 680 90061, 100-240 V, 17 W, batch no. and UL recognition mark.

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^{o}
Soldering	
Solderability	max. 240 ^{o}C, max. 6 s
Impact	
Free fall	1830 mm

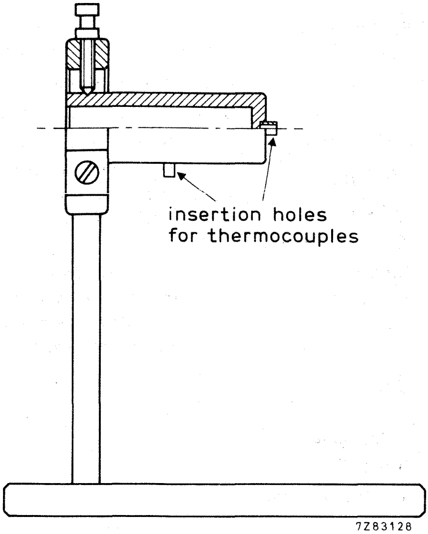
ELECTRICAL DATA

Measurements made in still air at an ambient temperature of + 23 ± 1 ^{o}C.

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V, after 20 min*	17 W ± 20%
Time to reach + 130 ^{o}C at 120 V*	max. 7 min
Temperature on standard test mounting after 20 min	
at 120 V	+ 172 ± 8 ^{o}C
at 240 V	max. 195 ^{o}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 ^{o}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 ^{o}C, measured inside test chamber	min. 10 MΩ
Ambient temperature range at zero power and at maximum voltage	−25 to + 60 ^{o}C

* Measured when mounted in standard test mounting of Fig. 2.

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



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 20900	iron-constantan
4304 101 20910	copper-constantan
4304 101 20920	nickelchrome-nickel

Thermocouples conform to DIN.

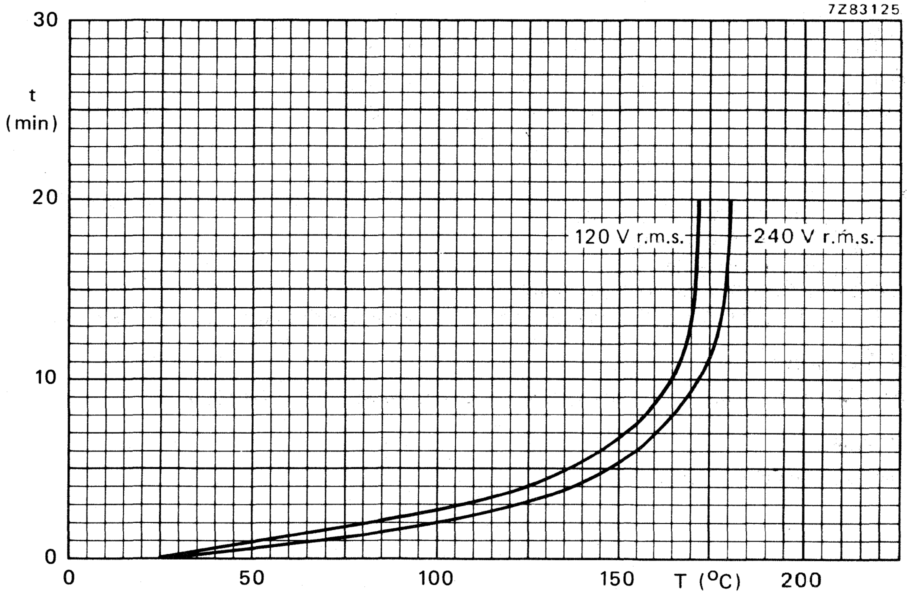


Fig. 3 Typical temperature versus time characteristics.
Measured in standard test mounting. T_{amb} = + 23 °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at –25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock –25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric withstanding voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly		450 h	
Cycle test at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly		1350 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		
Free fall	Ed	2 falls	
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	
Torsion	Uc	3 times	
Solderability	T par. 3.2.3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at –25 °C/ 16 h at + 60 °C.
2. Cycle: 20 min on/ 30 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

500 pieces per cardboard box.

PTC HEATING ELEMENT

QUICK REFERENCE DATA

Voltage range (r.m.s.)	100 to 240 V
Maximum inrush power at 120 V	200 W
Operating power at 120 V after 20 min	15 W ± 20%
Time to reach + 130 °C at 120 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

Heating element composed of a PTC thermistor moulded in a silicone rubber tube and two insulated solid copper wires.

MECHANICAL DATA

Dimensions in mm

Outlines

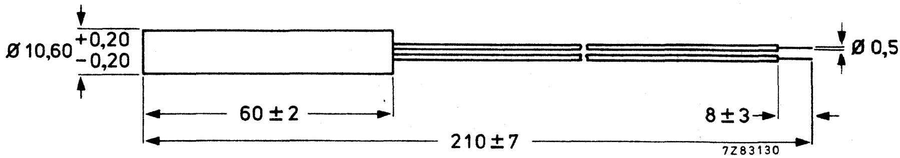


Fig. 1.

Marking

PHILIPS, 2322 680 90134, 100-240 V, 15 W, batch no. and UL recognition mark.

Mass	19 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

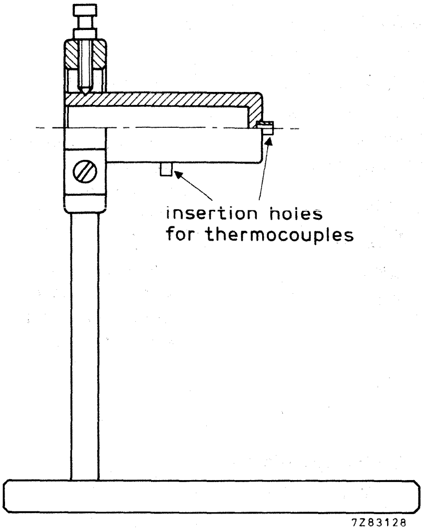
ELECTRICAL DATA

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 120 V	200 W
Operating power at 120 V. after 20 min*	15 W ± 20%
Time to reach + 130 °C at 120 V*	max. 7 min
Temperature on standard test mounting after 20 min	
at 120 V	+ 172 ± 8 °C
at 240 V	max. + 195 °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

* Measured when mounted in standard test mounting of Fig. 2.

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



Attention: Check correct mounting of thermocouples. If too large a temp. difference (3 °C for example) exists between the 2 thermocouples, it could be due to poor thermal contact with the tube. Silicone grease (e.g. Eccotherm TC4) should be used to ensure good thermal contact.

Fig. 2 Standard test mounting.

Catalogue number (for ordering):

	thermocouples
4304 101 21100	iron-constantan
4304 101 21110	copper-constantan
4304 101 21120	nickelchrome-nickel

Thermocouples conform to DIN.

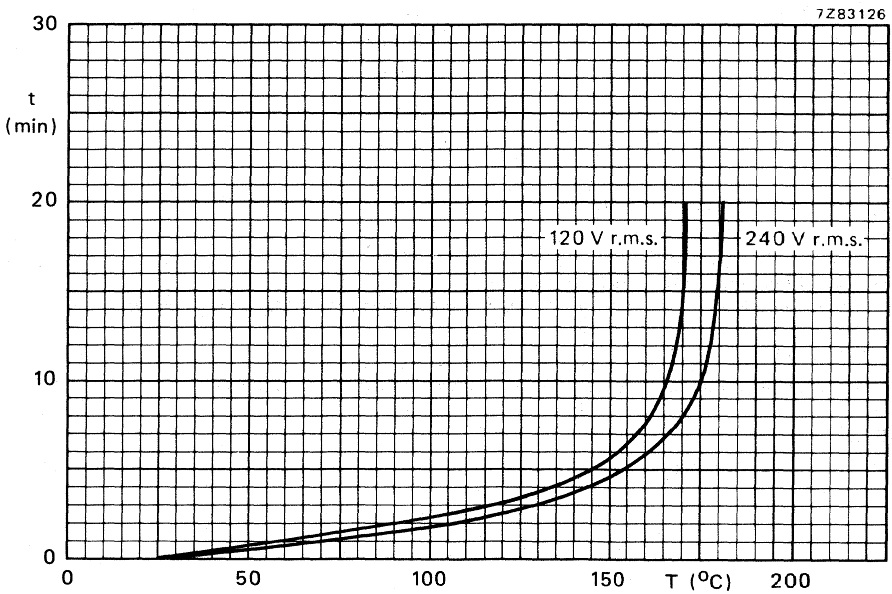


Fig. 3 Typical temperature versus time characteristics.
Measured in standard test mounting. T_{amb} = + 23 °C.

TESTS AND REQUIREMENTS

According to IEC 68 recommendations unless otherwise specified.

test	test method	duration	requirements
Cold at −25 °C	A	672 h	Deviation from spec. temp. on standard test mounting max. 7,5 °C
Storage at + 25 °C	H	1000 h	
Dry heat at + 60 °C	B	1000 h	
Thermal shock −25 °C to + 60 °C	Na	8 cycles (note 1)	
Damp heat at + 40 °C	C	500 h	Dielectric withstanding voltage and insulation resistance acc. to specification
Dissipation in damp heat, 10 V d.c.		336 h	
Dissipation at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly		450 h	
Cycle test at V_{rms} = 120 V and T_{amb} = 25 °C, elements mounted within tube assembly		1350 cycles (note 2)	
Vibration	Fc - B4	10-500 Hz, 10g, 6 h	(note 3)
Impact	E		
Free fall	Ed	2 falls	
Robustness of terminations	U		
Tensile strength	Ua	10 s	(note 4)
Bending	Ub	2 times	
Torsion	Uc	3 times	
Solderability	T par. 3. 2. 3	max. 6 s	(note 5)

Notes

1. Cycle: 8 h at −25 °C/16 h at + 60 °C.
2. Cycle: 10 min on/ 40 min off.
3. No visual or electrical defects.
4. Leads should neither come loose nor break.
5. Leads must be solderable initially and after 6 months storage with solder containing resin flux.

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with MIL-STD-105D.

PACKAGING

1000 pieces per cardboard box.

PTC THERMISTORS FOR OVERLOAD PROTECTION

A selection from our range of PTC thermistors which are suitable for use in overload protection circuits is given in Tables 3 and 4 with relevant electrical data. Dimensions associated with Figs 1 and 2 are given in Tables 1 and 2 respectively.

MECHANICAL DATA Dimensions in mm

Outlines

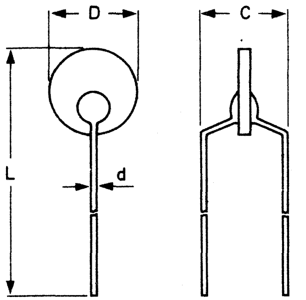


Fig. 1.

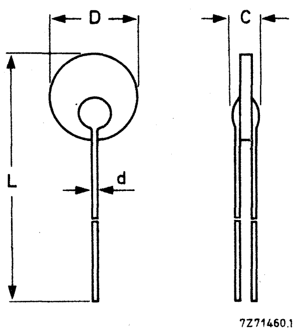


Fig. 2.

Table 1

line	D	L(±5)	d	C_{max}
1	20	60	0,8	13
2	16	58	0,8	13
3	12	56	0,8	13
4	10	55	0,8	13
5	8	54	0,8	13
6	20	60	0,8	11
7	16	58	0,8	11
8	12	56	0,8	11
9	10	55	0,8	11
10	8	54	0,8	11

Table 2

line	D	L(±5)	d	C_{max}
1	20	60	0,5	5,5
2	16	58	0,5	5,5
3	12	56	0,5	5,5
4	10	55	0,5	5,5
5	8	54	0,5	5,5
6	4,5	52,5	0,5	5,5
7	3	51,5	0,5	5,5
8	20	60	0,5	4
9	16	58	0,5	4
10	12	56	0,5	4
11	10	55	0,5	4
12	8	54	0,5	4
13	4,5	52,5	0,5	4
14	3	51,5	0,5	4

ELECTRICAL DATA

Table 3 Low-voltage PTC thermistors: V_{max} at +55 °C = 60 V; T_s = +115 °C

catalogue number	R_{25} Ω ±25%	$I_{stat\ peak}$ 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	dimensions mm figure	dimensions mm table/line
2322 664 91002	1,65	0,85	0,64	7,5	3	20	65	1	1/6
664 91003	1,65	0,75	0,57	6,5	3	15	45	2	2/8
663 91002	2,3	0,63	0,47	5,25	3	15	52	1	1/7
663 91003	2,3	0,50	0,37	4,5	3	10	34	2	2/9
662 91006	3,7	0,44	0,33	3,5	3	12	41	1	1/8
662 91007	3,7	0,35	0,26	2,75	3	7,5	25	2	2/10
662 91004	5,6	0,34	0,25	2,7	3	11	31	1	1/9
662 91005	5,6	0,26	0,195	2	3	6,5	21	2	2/11
661 91019	9,4	0,25	0,19	1,9	3	10	28	1	1/10
661 91021	9,4	0,18	0,135	1,3	3	5	16	2	2/12
660 91017	25	0,09	0,068	0,65	3	4	11	2	2/13
672 91016	55	0,059	0,044	0,4	3	3,5	10	2	2/14

Table 4 High-voltage PTC thermistors: V_{max} at +55 °C = 245 V; T_s = +115 °C.

catalogue number	R_{25} Ω ±25%	$I_{stat\,peak}$ 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	dimensions mm figure	dimensions mm table/line
2322 664 93014	3,7	0,55	0,41	4,9	6	20	18	1	1/1
664 93015	3,7	0,5	0,38	4,5	6	15,5	16	2	2/1
663 93006	6	0,4	0,3	3,0	6	16	16	1	1/2
663 93007	6	0,25	0,25	3,5	6	11	12	2	2/2
662 93017	10	0,27	0,2	1,8	7	12,5	14	1	1/3
662 93018	10	0,235	0,175	1,5	7	9	9	2	2/3
662 93015	15	0,215	0,162	1,3	7	11	13	1	1/4
662 93016	15	0,162	0,120	1	7	6,5	8	2	2/4
661 93001	25	0,150	0,115	0,9	7	10	12	1	1/5
661 93002	25	0,115	0,087	0,7	7	5,5	6	2	2/5
660 93006	70	0,059	0,045	0,25	8	4	5	2	2/6
660 93011	120	0,045	0,034	0,19	8	7	4,5	2	2/6
672 93003	150	0,036	0,027	0,1	8	4	3	2	2/7
660 93012	600	0,020	0,015	0,085	8	7	4	2	2/6
660 93013	1200	0,014	0,011	0,060	8	7	4	2	2/6
660 93014	1500	0,013	0,010	0,055	8	7	4	2	2/6

Definitions of terms used in Tables 3 and 4.

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}.

More extended information is available separately.

HUMIDITY SENSOR

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.

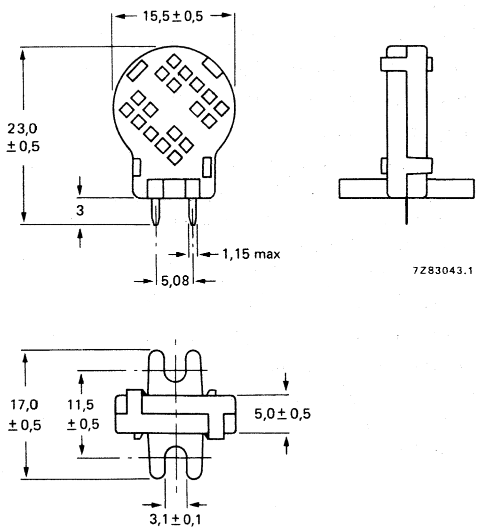


Fig. 1 Dimensions in mm.

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

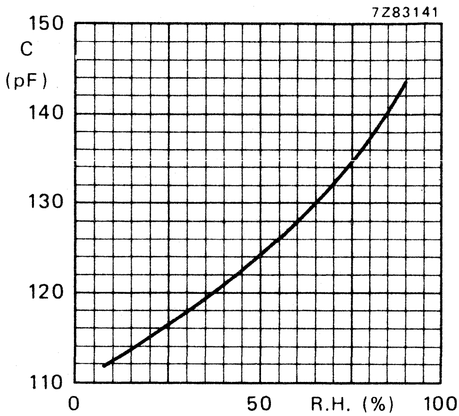


Fig. 2 Typical capacitance/relative humidity characteristic.

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
A.Q.L. 1,5% — Mechanical

PACKAGING

500 pieces per box.

NON-LINEAR RESISTORS

VOLTAGE DEPENDENT RESISTORS (VDR)

LIGHT DEPENDENT RESISTORS (LDR)

NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC)

HUMIDITY SENSOR

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