PASSIVE COMPONENTS

DATA HANDBOOK

Varistors, Thermistors and Sensors

BOOK PA02 1989

Philips Components

PHILIPS

VARISTORS, THERMISTORS AND SENSORS

For easy reference, catalogue numbers (12 digits) are at the top of each page.
Orders should always state the 12-figure catalogue number.

All dimensions on drawings are in mm unless otherwise indicated. According to the S.I. units the symbol K (Kelvin) is used instead of ^{o}C in combinations such as K/W. Also ΔT is in K. Atmospheric pressure is given in kPa instead of millibars, mm Hg, etc. 1000 mbar = 100 kPa.

Some devices are labelled "**Maintenance Type**". The relevant components are available for equipment maintenance only and are no longer recommended for equipment production.

Of those types labelled "**DEVELOPMENT DATA**" the specifications are subject to change without notice.

SELECTION GUIDE

NEGATIVE TEMPERATURE COEFFICIENT (NTC) THERMISTORS

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Temperature sensing and control	Basic	Radial leads	2322 640 5. . . .	69
		Radial leads	2322 640 6. . . .	73
		Radial leads	2322 642 6. . . .	109
		Radial leads	2322 645 series	129
	Special accuracy	Radial leads	2322 633 90001	63
		Radial leads	2322 640 10. . .	65
		Radial leads	2322 640 90012	97
		Moulded	2322 640 90013	97
		Moulded with metal strip	2322 640 98013	97
		Screw	2322 640 97013	97
		Steelcap	2322 640 95013	97
		Radial leads	2322 640 90031	105
		Radial leads	2322 645 90001	135
		Moulded with metal strip	2322 645 98001	135
		Screw	2322 640 97001	135
		Steelcap	2322 645 95001	135
		Radial leads	2322 645 90015	139
		Radial leads	2322 645 90022	143
	Assembly	Moulded	2322 640 90004	87
		Moulded with metal strip	2322 640 98004	87
		Moulded	2322 640 90005	91
		Moulded with metal strip	2322 640 98005	91
		Steelcap	2322 640 90024	101
		Steelcap	2322 640 90025	101
		Steelcap	2322 640 90034	101
		Long and insulated leads	2322 640 90056	107
		Screw	2322 642 7. . . .	115
		Radial leads	2322 645 90028	147
	High temperature	SOD27	2322 633 72224	59
			2322 633 73224	59
	Miniature	Glass encapsulated bead with radial leads	2322 626 1. . . .	43
			2322 626 2. . . .	47
		Bead with axial leads	2322 633 0. . . .	51
		Bead with axial leads	2322 633 1. . . .	51
		Glass encapsulated bead with axial leads	2322 633 2. . . .	55
	Naked disc	Disc	2322 611 9. . . .	39
Temperature compensation	Basic	Radial leads	2322 640 6. . . .	73
		Radial leads	2322 645 series	129
Surge current limiting	1 Watt	Radial leads	2322 610 1. . . .	35
	Low power	Radial leads	2322 642 6. . . .	113
	High current	Radial leads	2322 644 90005 to 90026	119
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POSITIVE TEMPERATURE COEFFICIENT (PTC) THERMISTORS

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Heating	See overview	Rectangular, circular		185
Degaussing	Mono	Radial leads	2322 662 93702	229
		Plastic housing	2322 662 96176	263
	Dual	Plastic housing	2322 662 96009	231
		Plastic housing	2322 662 96011	233
		Plastic housing	2322 662 96012	235
		Plastic housing	2322 662 96013	237
		Plastic housing	2322 662 96016	239
		Plastic housing	2322 662 96022	241
		Plastic housing	2322 662 96024	243
		Plastic housing	2322 662 96025	245
		Plastic housing	2322 662 96111	247
		Plastic housing	2322 662 96116	249
		Plastic housing	2322 662 96118	251
		Plastic housing	2322 662 96122	253
		Plastic housing	2322 662 96123	255
		Plastic housing	2322 662 96124	257
		Plastic housing	2322 662 96125	259
		Plastic housing	2322 662 96126	261
Overload protection	Basic	Radial leads	2322 660 0. . . 1	287
		Radial leads	2322 660 0. . . 3	269
		Radial leads	2322 661 0. . . 1	287
		Radial leads	2322 661 0. . . 3	269
		Radial leads	2322 662 0. . . 1	287
		Radial leads	2322 662 0. . . 3	269
		Radial leads	2322 663 0. . . 1	287
		Radial leads	2322 663 0. . . 3	269
		Radial leads	2322 664 0. . . 1	287
		Radial leads	2322 664 0. . . 3	269
		Naked disc	2322 660 1. . . 1	269
		Naked disc	2322 660 1. . . 3	287
		Naked disc	2322 661 1. . . 1	269
		Naked disc	2322 661 1. . . 3	287
		Naked disc	2322 662 1. . . 1	269
		Naked disc	2322 662 1. . . 3	287
		Naked disc	2322 663 1. . . 1	269
		Naked disc	2322 663 1. . . 3	287
		Naked disc	2322 664 1. . . 1	269
		Naked disc	2322 664 1. . . 3	287
		Radial leads	2322 660 9. . . .	311
		Radial leads	2322 661 9. . . .	311
		Radial leads	2322 662 9. . . .	311
		Radial leads	2322 663 9. . . .	311
		Radial leads	2322 664 9. . . .	311
		Radial leads	2322 660 91001	189
		Radial leads	2322 660 91006 to 91009	193

POSITIVE TEMPERATURE COEFFICIENT (PTC) THERMISTORS (continued)

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Overload protection	Basic	Radial leads	2322 660 93001	201
		Radial leads	2322 661 91002 to 91005	205
		Radial leads	2322 662 91001	211
		Naked disc	2322 662 93006	215
		Radial leads	2322 662 93036	219
		Radial leads	2322 662 93066	223
		Radial leads	2322 664 91086	265
		Radial leads	2322 672 91016	311
		Radial leads	2322 672 93003	311
	TPJ	DO7	2322 670 90003	315
	TPE	Plastic housing	2322 672 98001	333
	Small	Radial leads or disc	2322 672 91002 to 91035	317
	Motor protection	Insulated leads	2322 672 92045 to 92053	325

VARISTORS (VDR)

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Transient suppression	Basic	Available in:	2322 592 series	371
		Straight leads	2322 593 series	371
		Kinked leads	2322 594 series	371
		Flanged leads	2322 595 series	371
		On tap		
		In ammopack		
		Bulk		

LIGHT DEPENDANT RESISTORS (LDR)

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Switching	Basic	Sealed housing	2322 600 93001	399
			2322 600 93002	399
		Sealed housing	2322 600 94001	401
		Sealed housing	2322 600 95. . .	403

HUMIDITY SENSOR

PRODUCT FUNCTION	RANGE	OUTLINE	ORDERING CODE	PAGE
Sensing	Basic	Housing	2322 691 91001	405

NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS (NTC)

INTRODUCTION

Definition and composition

Negative temperature coefficient thermistors (NTCs) are resistive components, of which the resistance decreases as temperature increases. They are made from polycrystalline semiconductors, the compositions of which are a mixture of chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co) and nickel (Ni).

Manufacture

The manufacturing process is comparable to that of ceramics. After intensive mixing and the addition of a plastic binder, the mass is shaped into the required form, e.g. extrusion (rods) or pressing (discs), and fired at a temperature high enough to sinter the constituent oxide. New technologies have led to the sawing of isostatic pressed wafers, the compositions of which are very stable with, as a result, high accuracy and high reproducibility.

Electrical contacts are then added by burning them in with silver paste or by other methods, such as evaporation. Finally, leads (isolated or not), are fitted. Different encapsulations are possible, depending on the size of the ceramic and the application of the component.

Miniature NTC thermistors are made by placing a bead of oxide paste between two parallel platinum alloy wires and then drying and sintering. The platinum alloy wires are 60 μm in diameter and spaced 0.25 mm apart. During sintering, the bead shrinks onto the wires to make a solid and reliable contact. Miniature NTC thermistors are usually mounted in glass to protect them against aggressive gases and fluids.

Relationship of resistance with temperature

The conductivity (σ) of a material is its capacity to drive a current when a voltage is applied to it. As the current is driven by carriers that are free to move (i.e. which are not bound to atoms), then it follows that the conductivity will be proportional to the number of carriers (n) that are free and also to the mobility (μ) that those carriers can acquire under the influence of electrical fields. Thus:

$$\sigma = ne\mu$$

where e is the unit of electrical charge stored by each carrier.

Both n and μ are functions of temperature. For μ, the dependance on temperature is related to the interactions of a carrier with other carriers and with the total net amount of vibrating atoms, the vibration varying with temperature. It can be shown that:

$$\mu \propto e^{-q2/kT}/T$$

For n, the dependance on temperature can be explained in the following way: electrons are bound to atoms by certain energies. As one gives the electron an energy equal to, or greater than, the binding energy (e.g. by raising its temperature), there is a probability that the electron will become free to move. As for many semiconductors, this probability has the form of the well known Maxwell-Boltzmann distribution. Thus:

$$n \propto e^{-q1/kT}$$

Relationship of resistance with temperature (continued)

The total temperature dependence of the conductivity is:

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

In practice, the exponential factor is the most important. Remembering that resistivity is the inverse of conductivity, the following can be derived:

$$R = A\, e^{B/T} \text{ or } \log R = A + (B/T)$$

where A and B are parameters depending on each component (resistivity and shape).

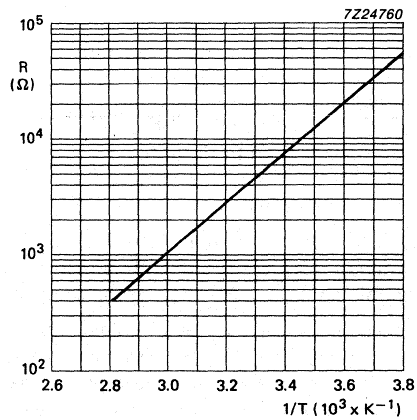


Fig.1 Resistance (in ohms) as a function of inverse of temperature (in 10^3 x K^{-1}) for a typical NTC.

Shape of a NTC curve and determination of B value

In Fig.1, resistance is plotted as a function of the inverse of temperature. Even in semi-log scale, it can be seen that this curve is not a straight line. This is due to the fact that A and B are not perfectly constant with temperature. However, over a wide range of temperatures, it may be assumed that these parameters are constant.

If this range is defined between T_1 and T_2, and it is assumed that the curve on this range could be approximated with a straight line, the slope of which will be B, this last value between T_1 and T_2 may be found as follows:

The resistance value is measured at T_1 and T_2.

$R_1 = A\, e^{B/T_1}$ and $R_2 = A\, e^{B/T_2}$

Dividing yields:

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

or:

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

solving for B gives:

$$B = \frac{1n\ R_1/R_2}{1/T_1 - 1/T_2}$$

In practice, B varies slightly with increasing temperature.

The temperature coefficient of a NTC may be derived from:

$\alpha = 1/R \,.\, dR/dT = -\, B/T2$

For the different materials, the constant B may vary between 2000 and 5500 K; e.g. a value of 3600 K yields α = –4% per K at a temperature of 300 K.

A and B are assumed to be constant between T_1 and T_2 ($B_{T1/T2}$)

In practice, most NTC's are specified with a reference value at 25 °C and a constant B value between 25 °C and 85 °C. For commodity reasons, the curves printed in this handbook show the resistance as a function of temperature, instead of its inverse.

V/I characteristics

Figure 2 shows the relationship between current and voltage drop through the NTC thermistor heated by this current to a temperature much higher than the ambient temperature.

With very small values of current, it can be seen that the curve remains straight, following an isoresistive line. Remembering that an isoresistive line is in fact an isothermal line (R = fct[T]), it indicates that the power consumption is too small to register a distinct rise in temperature.

For higher current intensities, the temperature rises by Joule effect (P = VI). The equilibrium temperature is reached when the power dissipated by the NTC is in equilibrium with the power applied to it. It can be seen that as the dissipated power is dependent on the environment, the equilibrium will also depend on it and thus the V-I characteristic also. The characteristic shown in Fig.2 was measured at a constant ambient temperature after equilibrium had been reached.

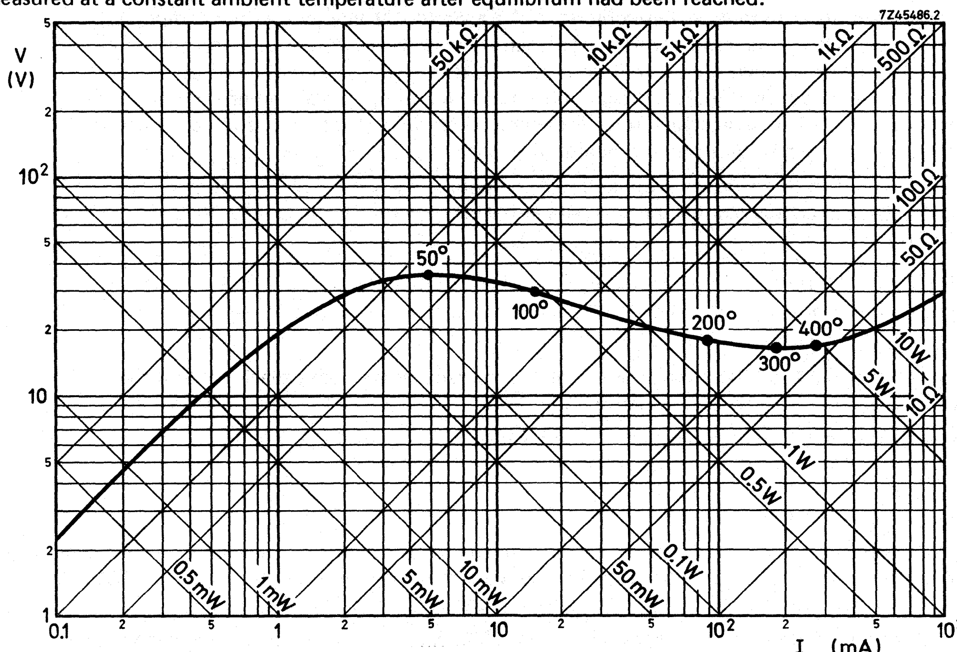


Fig.2 Voltage as a function of the current characteristics of an NTC thermistor.

Assuming:

(A) a constant temperature throughout the body of the thermistor;
(B) the heat transfer to be proportional to the difference in temperature between the thermistor and the surrounding medium (which is true for low temperatures).

V/I characteristics (continued)

In case of equilibrium:

$$W = VI = \delta(T - T_0)$$

in which T_0 is the ambient temperature and δ the dissipation factor (defined in the following paragraph).

From this relationship, it is obvious that the temperature of the component will be that of its surroundings if the power applied to the component (W) is equal to zero (power off value). If the applied power is not very small (< 0.01 W), then T is no longer equal to T_0 and will be strongly dependent on δ (power on conditions).

Because it is not possible to define δ without any doubt, (δ is not dependent on the component itself, but also on special housing, if any, convection, turbulence, etc.), all components are specified with their power off values.

To choose a component that will be used in a 'power on' application, it is necessary to determine δ in that application.

SPEED OF RESPONSE

Thermal Time Constant

The thermal time constant is an indication of the time that a component needs to reach thermal equilibrium. This constant depends on two important parameters.

One is the thermal capacity (H) of the component, i.e. the energy that must be applied to the component in order to raise its temperature by 1 Kelvin (or the energy that the component must lose in order to lower its temperature by 1 Kelvin). The units are thus quoted in Joules/Kelvin. The second parameter is called the dissipation factor (δ). If the temperature of a component rises, it will tend to dissipate energy. This dissipation will depend on the surroundings and also on the component itself. The dissipation factor is defined as the ratio of the change in power dissipation with respect to the resultant body temperature change (units in W/K).

If a step change in temperature is applied to a component e.g. from high (T_1) to low (T_0) temperature, the energy lost by the component ($-HdT$) is equal to the energy dissipated by it ($\delta[T - T_0]dt$).

$$-HdT = \delta(T - T_0)dt$$

This equation yields:

$$T - T_1 = (T_0 - T_1)e^{-t/\tau}$$

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

The temperature value when the time elapsed is ($t = \tau$) is given in the formula:

$$T - T_0/T_1 - T_0 = (1 - e^{-1}) = 0.632$$

This equation gives the following definition:

The thermal time constant is the time required for the temperature of a thermistor to change by 63.2% of the difference between its initial and final body temperatures (in accordance wit IEC 539; 85 ^{o}C and 25 ^{o}C respectively), when subjected to a step function temperature change.

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

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

– by cooling in air under zero power conditions (T_C)
– by warming or cooling, transferring the thermistor from ambient temperature of + 25 °C to a bath with a fluid with a higher or lower temperature under zero power conditions (T_r, termed 'response time' in the data sheets).

Tolerances on the Nominal NTC Specification

As already mentioned, an NTC thermistor is normally specified by giving a reference value (generally R_{25}) and the B value ($B_{25/85}$). Unfortunately, the manufacturing process dictates that identical components cannot be guaranteed, so there are some tolerances.

These tolerances can mean an upward or downward shift in the resistance value, equal at all temperatures due to, for example, soldering tolerances. The entire curve moves equally up or down:

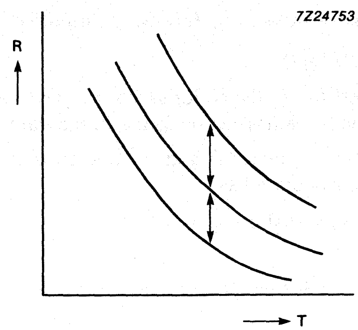


Fig.3 Effect of soldering as a function of resistance against time.

This tolerance is usually indicated by giving the shift at the reference temperature, so for example, R_{25} = 10 kΩ ± 5%.

A tolerance also exists on the slope of the curve. Because the B value is an indication of that slope, it is normally indicated as a tolerance on $B_{25/85}$. This is covered mainly by variations in the material composition and the effect of sintering on the material.

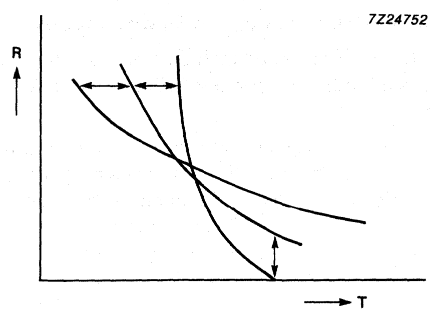


Fig.4 Effect of sintering on resistance against time.

The effect of the slope or the B-value deviation on the resistance at several temperatures can be calculated.

Tolerances on the Nominal NTC Specification (continued)

The fundamental equation of a NTC is:

$R_n\ (T) = R_{ref}\ ^{B(1/T - 1/T_{ref})}$

where R_n and B are nominal values (specified values without any tolerance).

If B is not a nominal value, it is expressed as:

$R\ (T) = R_n\ (T) + \Delta R(T) = R_{ref}\, e^{\,(B + \Delta B)\ (1/T - 1/T_{ref})}$

where $\Delta R(T)$ is the absolute deviation at temperature T.

$\Delta R(T) = R_{ref}\ [\ e^{\,(B + \Delta B)\ (1/T - 1/T_{ref})} - e^{\,B(1/T - 1/T_{ref})}]$

If relative deviation is applied:

$\Delta R(T)/R_n\ (T) = e^{\Delta B(1/T - 1/T_{ref})} - 1$

Developing this equation (Taylor's formulae), the following simplified expression can be derived:

$\Delta R(T)/R_n(T)\ (\text{in }\%) = \Delta B\ (1/T - 1/T_{ref})$

This calculation has been performed for all the major sensor ranges to be found in this handbook, where 'R deviation due to B tolerance' values can be found in the data tables.

If the R deviation due to B tolerance, is called 'Y' and the tolerance at the reference temperature 'X', then the total tolerance can be calculated as:

$Z = [(1 + X/100) \times (1 + Y/100) - 1] \times 100$

or, $Z = X + Y$ (approximation)

If TC = temperature coefficient and ΔT = temperature deviation,

$\Delta T = Z/TC$

Example: at 0 °C, let X = 5%, Y = 0.089% and TC = 5.08%/K, then:

$Z = \{[1 + (5/100)] \times [1 + (0.89/100)] - 1\} \times 100$

$= \{1.05 \times 1.0089 - 1\} \times 100 = 5.9345$ or 5.93%

$\Delta T = Z/TC = 5.93/5.08 = 1.167$ or 1.17 °C

Hence, a NTC having a R_{25} value of 10 kΩ has a value of 32.51 kΩ between +1.17 °C and −1.17 °C.

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

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

The tolerances in the reference points can be expressed either as a temperature deviation for the reference resistance or as a resistance tolerance at the reference temperature. This has no influence on the resulting measuring error which is minimal in the temperature region between the reference points, as illustrated in Fig.5.

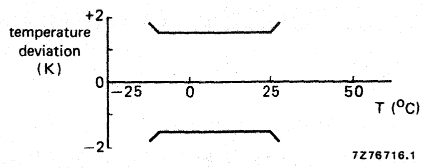


Fig.5 Temperature measurement at more than one point.

The 2 or 3-point sensors are particularly suited for applications with the following characteristics:

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

HOW TO MEASURE NTC THERMISTORS

The published R_T values are measured at the temperature T.

The published B-value at 25 °C is the result of a measurement at 25 °C and one at 85 °C, hence these values should be used when checking.

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

- Never measure thermistors in air; this is quite inaccurate and gives deviations of 1 or 2 K. For measurement at room temperature or below, use petrol or some other non-conductive and non-aggressive fluid. For higher temperatures use oil, preferably silicon oil.
- Use a thermostat with an accuracy of better than 0.1 °C. Even if the liquid is well stirred, there is still a temperature gradient in the fluid. Measure the temperature as close as possible to the NTC.
- After placing the NTC in the thermostat, wait until temperature equilibrium between the NTC and the fluid is obtained. For some types this may take more than 1 minute.
- Keep the measuring voltage as low as possible otherwise the NTC will be heated by the measuring current. Miniature NTC thermistors are especially sensitive in this respect. Measuring voltages of less than 0.5 V are recommended.
- For high temperature measurements it is recommended that stem correction be applied to the thermometer reading.

CHOICE OF TYPE

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

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

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

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

Deviating characteristics

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

Suppose an NTC must have a resistance of 50 Ω at 30 ^{o}C and 10 Ω at 100 ^{o}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 a 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. It should be remembered that the temperature coefficient of the combination will always be lower than that of the NTC thermistor alone.

Remarks on the use of NTC Thermistors

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

For temperature measurements do not use too high a voltage on the NTC thermistor as self-heating may cause incorrect readings. The dissipation constant indicates the maximum permissible measuring power, if an error of 1 ^{o}C is allowed.

GLOSSARY OF TERMS

Resistance

Also called nominal resistance. Formerly specified at only one temperature, or sometimes at two or maximum three. Now new technologies allow the specification of resistance values on all application ranges for several types.

Tolerance on resistance

The limits of the values that the resistance can take at the reference temperature.

B value

The B value may be calculated using the following formula:

$$\frac{\ln R_1/R_2}{1/T_1 - 1/T_2}$$

where R_1 and R_2 are the nominal values of resistance at T_1 and T_2.

Tolerance on B value

The limits of the value that B can take due to the process variations.

R tolerance due to B deviation

Due to the tolerance on the B value, the limits of the value that R can take at a certain temperature increase with the difference of that temperature to the reference temperature.

Tolerance on R at a temperature different to T_{ref}

The sum of the tolerances on resistance and tolerance due to B deviation.

α value

Variation of resistance (in %) for small variations of temperature around a defined temperature.

Maximum dissipation

Maximum power which could be applied without any risk of failure.

APPLICATIONS

Applications of NTC's may be classified into three main groups depending on their physical properties:

(1) Applications in which advantage is taken of the dependence of the resistance on the temperature, shown in the formula:

$$R = f(T)$$

This group is split into two sub sections:

(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.

(2) 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.

(3) 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 is so high, that a part of the $V = f(I)$ curve shows a negative slope.

The classifications given above are supported by practical examples in Figs 6 to 29.

APPLICATION EXAMPLES

Application (1) (a) — Temperature sensing

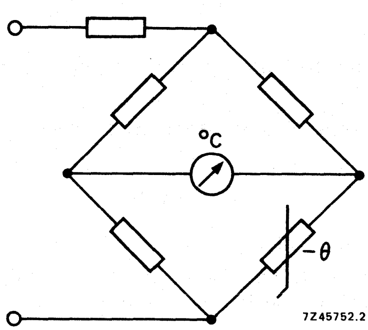


Fig.6 Temperature measurement in industrial and medical thermometers.

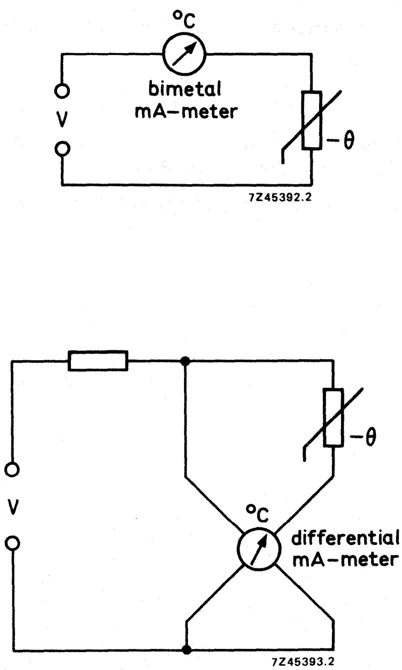


Fig.7 Temperature measurement in cars. Cooling water measurements with bimetal or differential milliammeters.

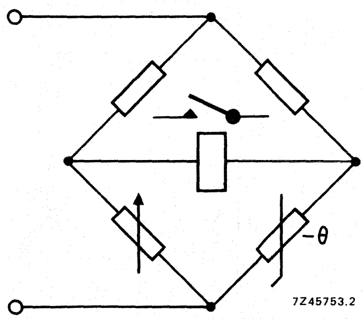


Fig.8 Temperature measurement with a bridge incorporating an NTC thermistor and a relay or a static switching device.

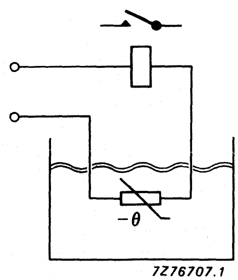


Fig.9 Liquid level control.

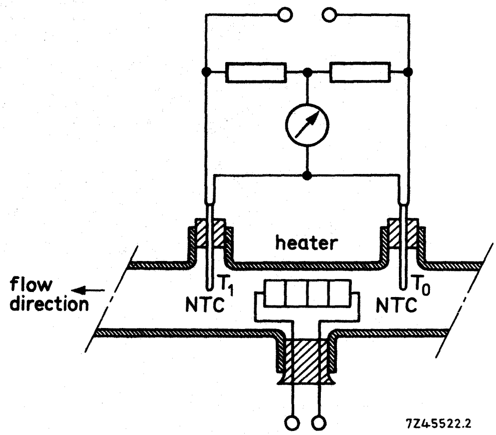


Fig.10 Flow measurement of liquids and gases. The temperature difference between T_1 and T_0 is measured for the velocity of the fluid.

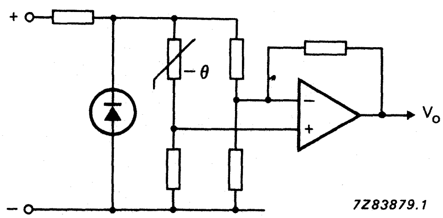


Fig.11 Temperature sensing bridge with amplifier. The op-amp acts as differential amplifier. The sensitivity can be very high.

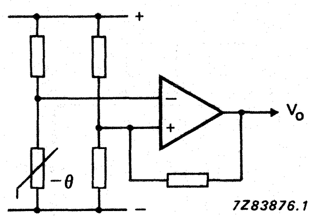


Fig.12 Basic temperature sensing configuration. The operational amplifier, e.g. type NE532, acts as a Schmitt trigger. The transfer characteristic is shown in Fig.13.

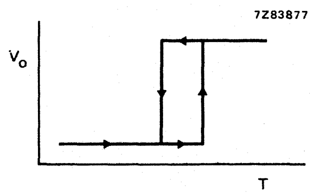


Fig.13 Transfer characteristic of circuit shown in Fig.12.

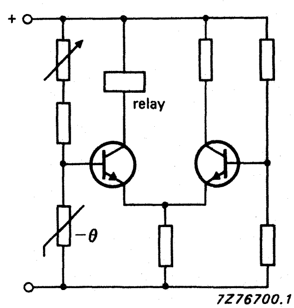


Fig.14 Simple thermostat.

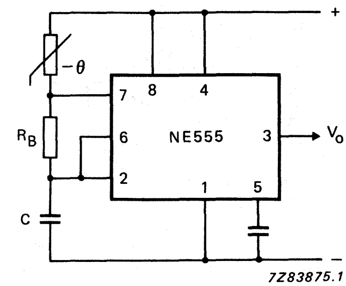


Fig.15 Temperature controlled oscillator. This is a simple interface circuit for digital and microcomputer-controlled systems. The frequency of the output pulses is proportional to the temperature of the NTC thermistor. See Fig.16.

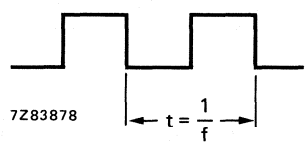


Fig.16 Characteristic of circuit shown in Fig.15.

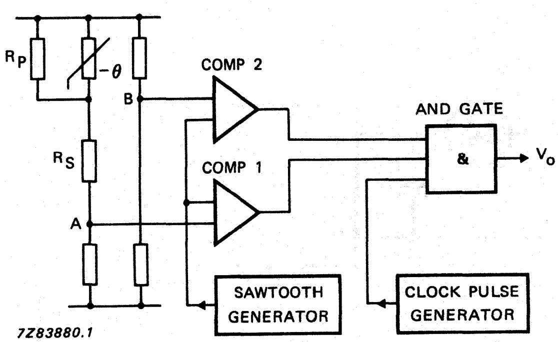


Fig.17 Temperature sensing bridge with 0 °C offset and analogue to digital conversion. Due to R_p and R_s the voltage at point A varies linearly with the temperature of the NTC thermistor. The voltage at point B is equal to the voltage at point A when the temperature of the NTC thermistor is 0 °C. Both voltages are fed to the comparator circuit. See also Fig.18.

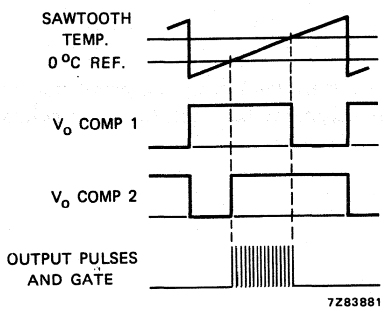


Fig.18 Characteristic of circuit shown in Fig.17.

Application (1) (b) — Limiting

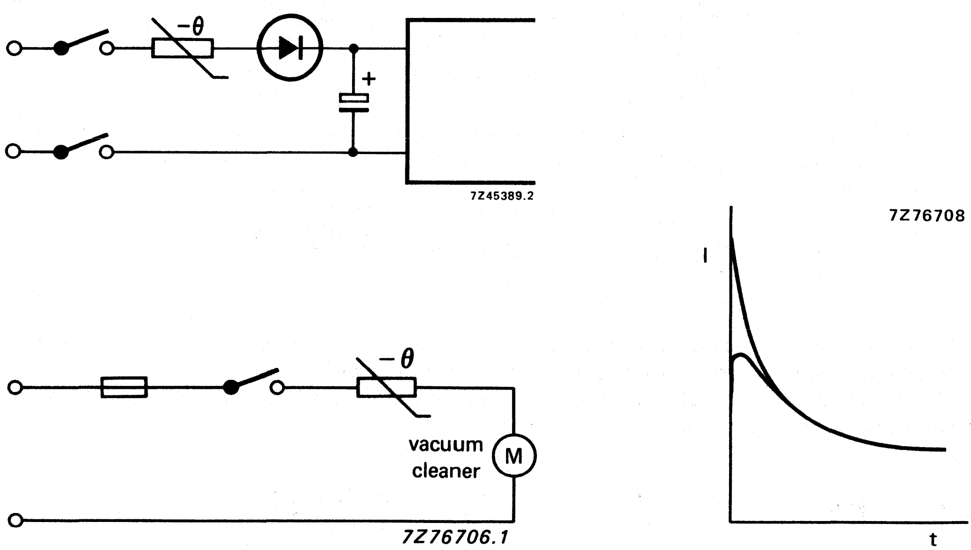


Fig.19 Inrush current limiter. e.g. for protection of Si-diodes (allowing similar types to be used), fuses and switches.

Application (2) – Timing

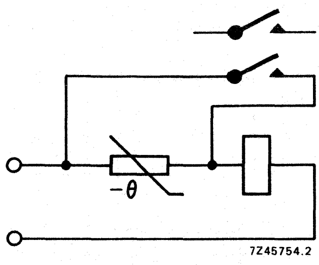


Fig.20 Delaying action of relays. Due to the thermal inertia of the NTC, it takes some time before the relay is activated. If necessary the NTC can be short-circuited after the relay is activated thus leaving the NTC time for cooling.

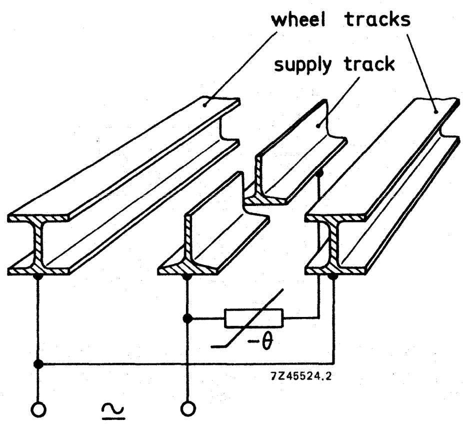


Fig.21 Model trains. As soon as the train comes on the isolated supply trip, it stops. The NTC heats up and gradually the train starts again.

Application (3) — Compensation

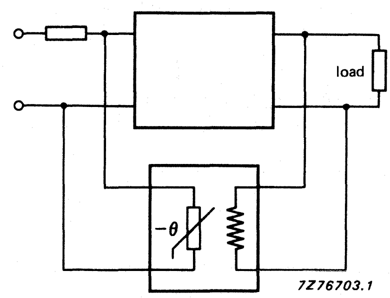


Fig.22 Gain compensation or gain control with an indirectly heated NTC.

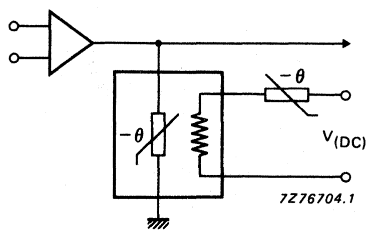


Fig.23 Compensation for the influence of ambient temperature variations in an h.f. amplifier.

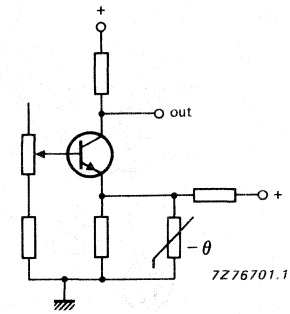


Fig.24 Stabilization with temperature of an a.g.c. amplifier in a television set.

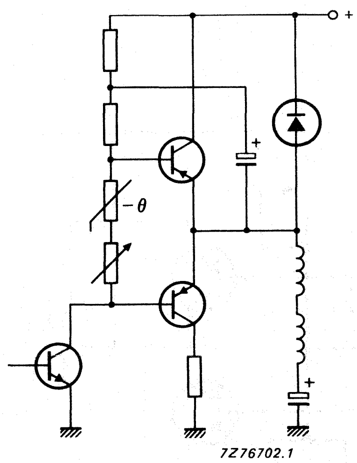


Fig.25 Compensation of drift in field deflection coils. The influence of the positive temperature coefficient of the copper windings is compensated by means of an NTC thermistor.

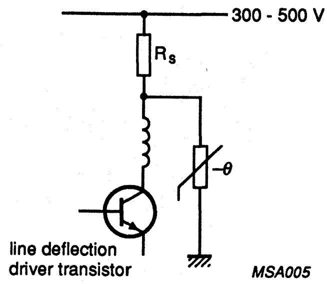


Fig.26 Constant current (sure start-up) for line deflection stage.

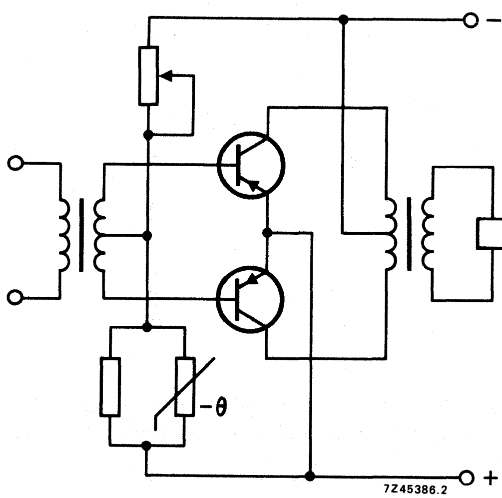


Fig.27 Temperature compensation in transistor circuits. Push-pull compensation.

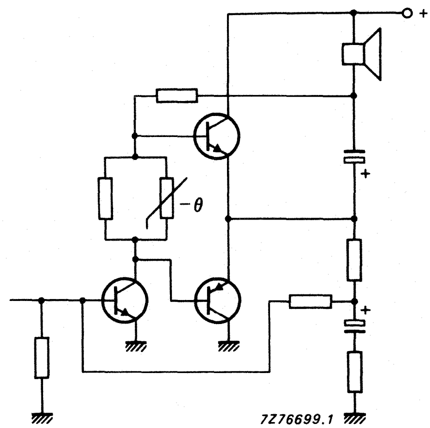


Fig.28 Transformerless audio output stage with temperature compensation.

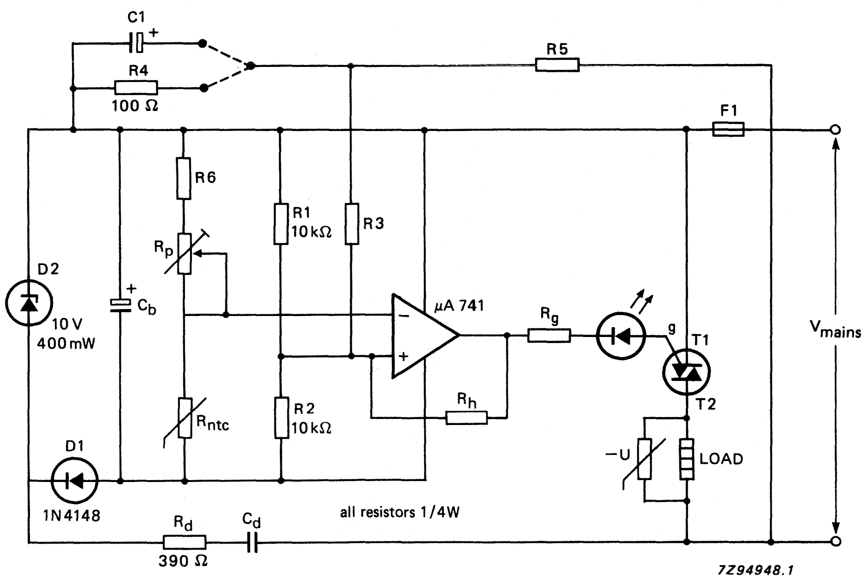


Fig.29 Thermostat for room temperature control.

NTC THERMISTORS
low power 1 Watt range

Features

- Cost effective
- Thermistor for surge current limiting under low power dissipation conditions

SURGE CURRENT LIMITING

QUICK REFERENCE DATA

Resistance value at + 25 °C	4 to 33 Ω ←
$B_{25/85}$-value	2800 to 3250 K ←
Maximum dissipation	1 W
Dissipation factor	10 mW/K
Thermal time constant	60 s approx.
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

DESCRIPTION

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

MECHANICAL DATA

Outlines

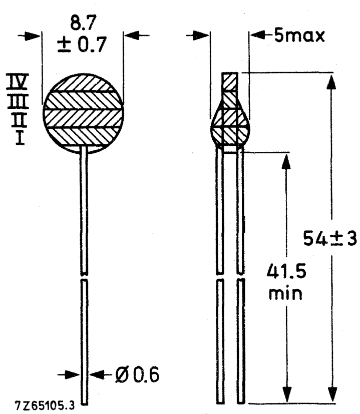


Fig.1 Component outline.

Marking

The thermistors are marked with three colour bands showing their resistance value (R_{25}) in code as indicated in Table 1. Thermistors with a tolerance on R_{25} of 10% have a fourth band coloured silver.

Mass

1.0 to 1.3 grams

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

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

PACKAGING

250 thermistors in a cardboard box.

ELECTRICAL DATA

Maximum dissipation *	1 W
Dissipation factor *	10 mW/K approx.
Thermal time constant *	60 s approx.
Heat capacity *	0.6 J/K approx.
Operating temperature	
at zero power	−25 to + 125 ^{o}C
at maximum power	0 to + 55 ^{o}C

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

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

suffix of catalogue number		R_{25}	$B_{25/85}$ ± 5%	temperature coefficient	colour code		
tol. ± 10%	tol. ± 20%	Ω	K	%/K	I	II	III
2408	1408	4	2800	−3.15	yellow	black	gold
2808	1808	8	2900	−3.25	grey	black	gold
2159	1159	15	3125	−3.40	brown	green	black
2339	1339	33	3250	−3.65	orange	orange	black

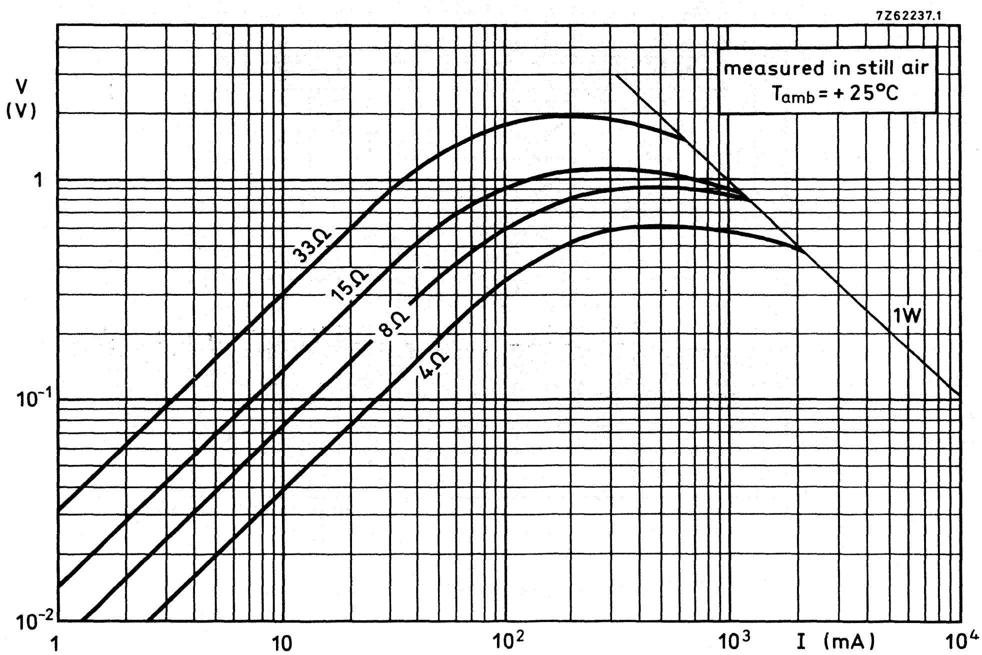


Fig.2 Typical voltage/current characteristics.

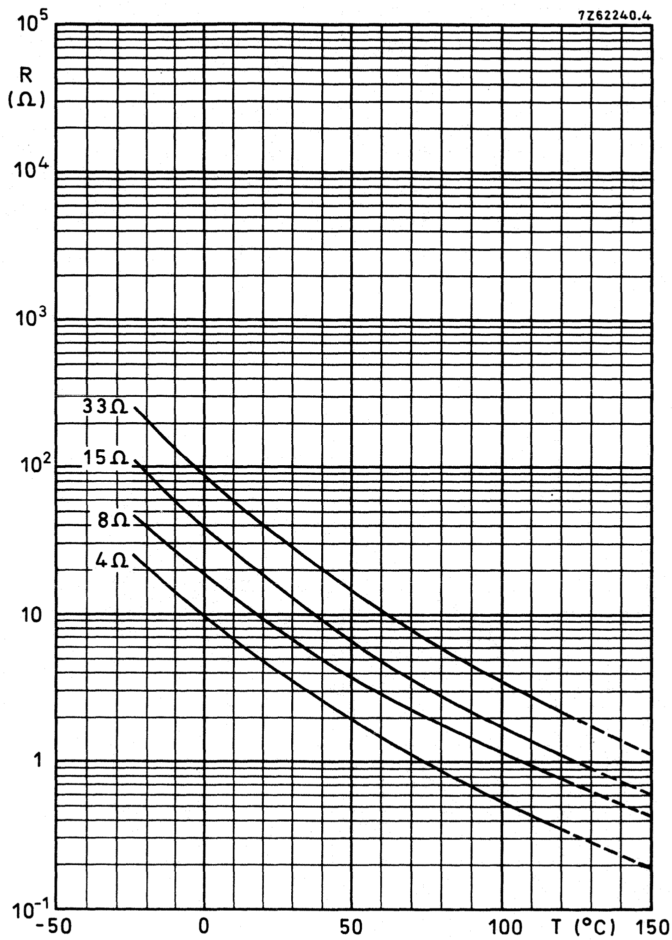


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTOR
naked disc range

Features

- Low price
- Proven quality

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value	see Table 1
$B_{25/85}$ value	see Table 1
Temperature coefficient	see Table 1
Dissipation factor	see Table 1

APPLICATION

Temperature sensing of coolant in motor cars. The thermistors are normally used under power on conditions (power causing self-heating of the NTC).

DESCRIPTION

Disc thermistors (without leads) having a negative temperature coefficient.

MECHANICAL DATA

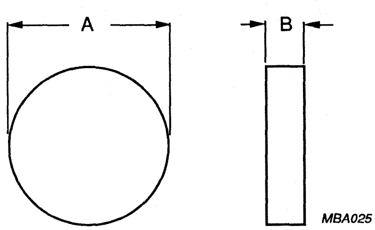


Fig.1 Component outline; see Table 1 for dimensions.

RANGE INFORMATION

Climatic category	25/125/56
Packaging	1000 pieces

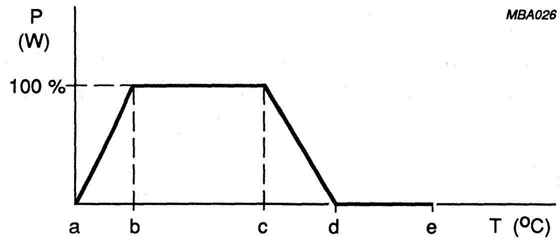


Fig.2 Derating curve; see Table 1 for curve values.

Table 1 Type information 2322 611 900 . .

Resistance at (Ω)	90025	90027	90028	90035	90036	90037	90039
−20 °C					6480 ± 1000		
0 °C					2450 ± 320		
20 °C					1040 ± 118		
25 °C	2100 (*)	930 ± 10%		2577 (*)	845 (*)	562 (*)	930 (*)
40 °C			304.5 ± 8.8%		488 ± 40		
54.5 °C				754.5 ± 5%			
60 °C	520 ± 60				245 ± 20	167 ± 9.7%	268 ± 9.5%
90 °C					102 ± 6		
100 °C	144 ± 10	84.5 ± 7%	39.6 ± 5%			52.5 ± 7.5%	84.5 ± 7%
110 °C				121.6 ± 3%			
120 °C			23 ± 8%		47.5 ± 3	31.3 ± 6%	
140 °C	48 ± 4						
$B_{25/85}$ (K)	3977 (*)	3600 (*)	3950 (*)	4093 (*)		3500 (*)	3550 (*)
Temperature coefficient (approx.) (%/K)	−4.4	−4.05	−4.44	−4.6		−3.8	−4
Derating curve max. dissipation (W)	0.5	0.25	0.25	0.5	0.5	0.3	0.25
a (°C)	−55	−25	−30	−55	−40	−40	−25
b (°C)	−25	−25	−25	−25	−25	−25	−25
c (°C)	55	55	55	55	55	55	55
d (°C)	85	85	85	85	85	85	85
e (°C)	155	125	155	125	125	125	125
Weight (approx.) (grams)	0.15	0.15	0.14	0.1	0.11	0.09	0.1
Outline A (mm)	4.7 ± 0.2	4.7 ± 0.2	4.7 ± 0.2	5.2 − 0.3	4.4 ± 0.3	4.7 ± 0.2	4.4 ± 0.3
Outline B (mm)	1.2 ± 0.3	1.4 ± 0.6	1.7 to 2.2	1.14 to 1.9	1.4 ± 0.3	1 ± 0.3	1.3 ± 0.3
Dissipation factor (approx.) (mW/K)		4.8	6.6				
Marking	none	orange stripe	none	yellow stripe	none	none	none

* for information only.

NTC THERMISTORS

glass encapsulated miniature bead

Features

- Small diameter
- Quick response to changes in temperature
- High stability over long time periods
- High temperature operation
- Resistant to aggressive environments
- High degree of isolation between tip and environment

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at 25 °C	1 kΩ to 1 MΩ
Tolerance on R_{25} value	± 5%, ± 10%
$B_{25/85}$ value	2075 to 4100 K
Tolerance on $B_{25/85}$ value	± 5%
Response time	1 s approx.
Thermal time constant	10 s approx.
Dielectric withstanding voltage (RMS)	1500 V min.
Operating temperature range	
at zero power	−55 to 200 °C, or
	−55 to 300 °C
at maximum power	0 to 55 °C

APPLICATION

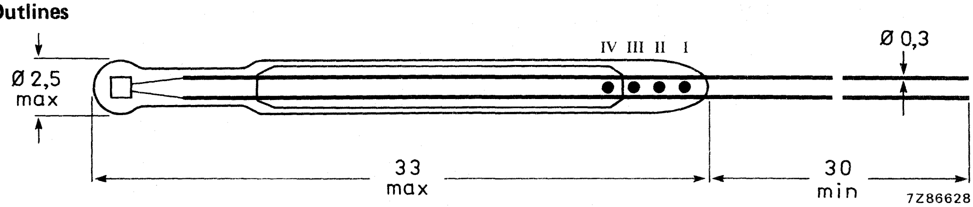
Temperature measurement and control up to 300 °C in 'aggressive' environments. Also level sensing.

DESCRIPTION

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

MECHANICAL DATA

Outlines



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

Fig.1 Component outline.

Marking
Four colour dots on the glass envelope, see Table 1 for colour code.

Mass
0.27 g approximately.

Mounting
In any position by soldering.

Soldering

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

Inflammability
Uninflammable.

Impact

Free fall	100 mm

Robustness of terminations

Tensile strength	2.5 N
Bending	1.25 N
Resistance to solvents	in accordance with IEC 68-2-45, resistant to R113 at T_{amb}.

PACKAGING

100 thermistors in a cardboard boax.

ELECTRICAL DATA

Unless otherwise specified, measured in accordance with IEC publication 539.

Maximum dissipation at + 55 °C	100 mW
Dissipation factor	1.2 mW/K approx.
Thermal time constant	10 s approx.
Response time (see note 1)	1 s approx.
Operating temperature range (see Fig.2 and Table 1)	
at zero power	−55 to + 200 °C, or + 300 °C
at maximum power	0 to + 55 °C
Dielectric withstanding voltage (RMS) between terminals and glass envelope	min. 1500 V
Insulation resistance between terminals and glass envelope at 100 V (DC)	min. 100 MΩ

Note

1. Response time in silicone oil MS 200/50. The response time in silicone oil is the time necessary to change of 63.2% of the total difference between the initial and the final body temperature, when subjected to a step function change in ambient temperature. Step change: initial temperature: air at 25 °C; final temperature: oil (MS 200/50) at 85 °C.

Table 1 Catalogue number 2322 626 1 ....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code*		
tol. ± 5%	tol. ± 10%	kΩ	K	%/K	I	II	III
3102	2102	1	2075	–2.3	brown	black	red
3222	2222	2.2	2285	–2.6	red	red	red
3472	2472	4.7	2485	–2.8	yellow	violet	red
3103	2103	10	3750	–4.2	brown	black	orange
3223	2223	22	3560	–4.0	red	red	orange
3473	2473	47	3750	–4.2	yellow	violet	orange
3104	2104	100	3900	–4.4	brown	black	yellow
3224	2224	220	3860	–4.3	red	red	yellow
3474	2474	470	3950	–4.5	yellow	violet	yellow
3105	2105	1000	4100	–4.6	brown	black	green

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

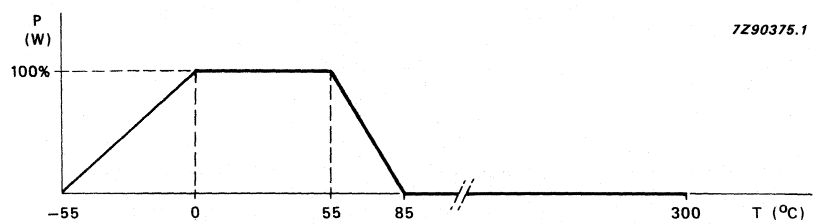
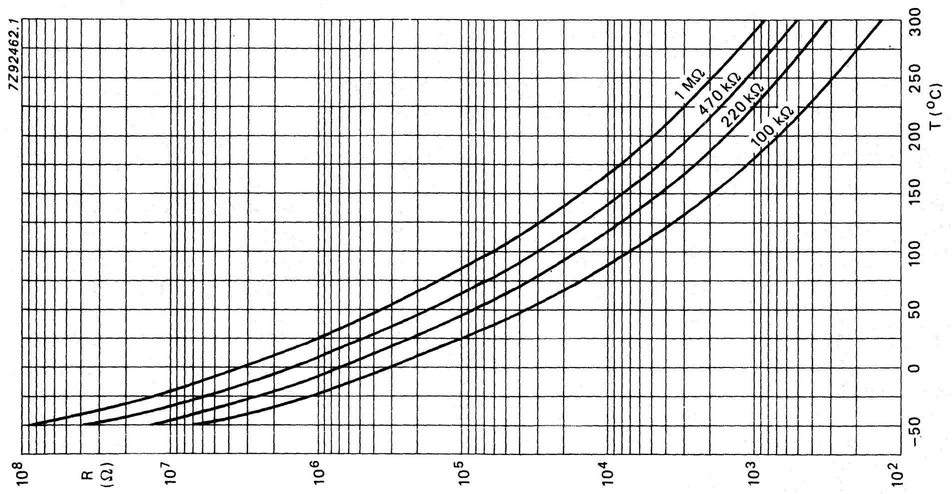


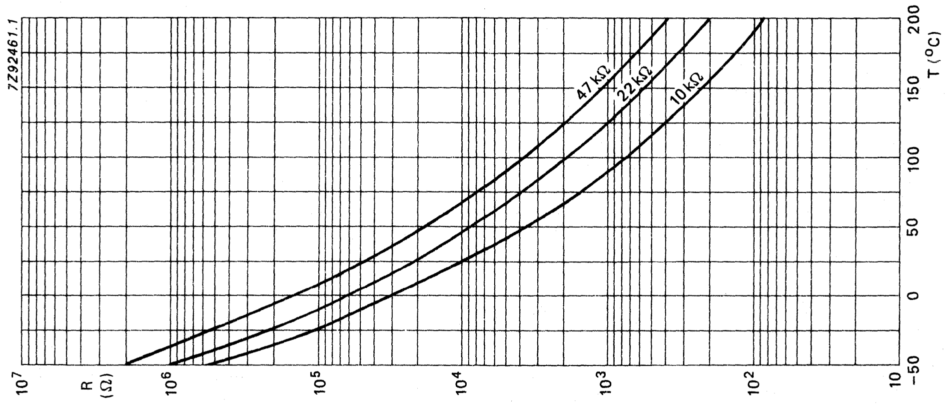
Fig.2 Derating curve.

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	–40 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = –0.2%
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C, 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/85}$ value of 3797 K.





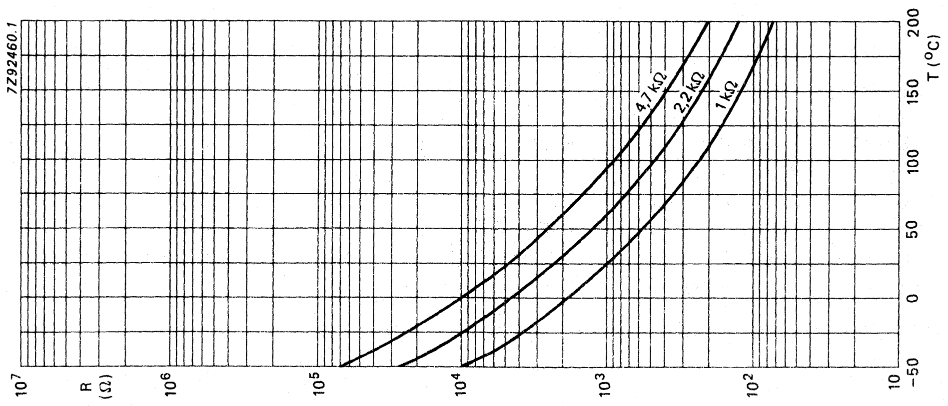


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS

glass encapsulated miniature bead

Features

- Small diameter
- Quick response to changes in temperature
- Very high long term stability
- High temperature uses
- Resistant to aggressive environments

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at 25 °C	1 kΩ to 1 MΩ
Tolerance on R_{25} value	± 5%, ± 10%
Tolerance on $B_{25/85}$ value	± 5%
Thermal time constant	7.5 s approx.
Response time	0.85 s approx.
Operating temperature range	
at zero power	−55 to 200 °C, or −55 to 300 °C
at maximum power	0 to 55 °C

APPLICATION

Temperature measurement and control up to 300 °C. Also level sensing.

DESCRIPTION

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

MECHANICAL DATA

Outlines

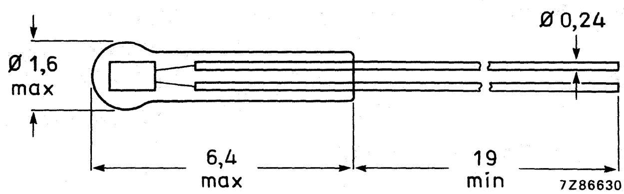


Fig.1 Component outline.

Marking

None

Mass

33 mg approximately

Mounting

In any position by soldering

Soldering

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

Inflammability

Uninflammable

Impact

Free fall 100 mm

Robustness of terminations

Tensile strength 1.0 N

PACKAGING

100 thermistors in a cardboard box

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539

Table 1 Catalogue number 2322 626 2....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	T_{max}	temperature coefficient at 25 °C
tol. ± 5%	tol. ± 10%	kΩ	K	°C	%/K
3102	2102	1	2075	200	–2.3
3222	2222	2,2	2285	200	–2.6
3472	2472	4,7	2485	200	–2.8
3103	2103	10	3750	200	–4.2
3223	2223	22	3560	200	–4.0
3473	2473	47	3750	200	–4.2
3104	2104	100	3900	300	–4.4
3224	2224	220	3860	300	–4.3
3474	2474	470	3950	300	–4.5
3105	2105	1000	4100	300	–4.6

Maximum dissipation at + 55 °C 100 mW

Dissipation factor 0.8 mW/K approx.

Thermal time constant 7.5 s approx.

Response time (see note) 0.85 s approx.

Operating temperature range (Fig. 2 and Table 1)
- at zero power –55 to + 200 °C, or + 300 °C
- at maximum power 0 to + 55 °C

Dielectric withstanding voltage (RMS)
- between terminals and glass envelope min. 100 V

Insulation resistance between terminals
- and glass envelope at 10 V (DC) min. 10 MΩ

Note: Response time in silicone oil MS 200/50. The response time in silicone oil is the time necessary to change of 63.2 % of the total difference between the initial and the final body temperature, when subjected to a step function change in ambient temperature. Step change: initial temperature: air at 25 °C; final temperature: oil (MS 200/50) at 85 °C.

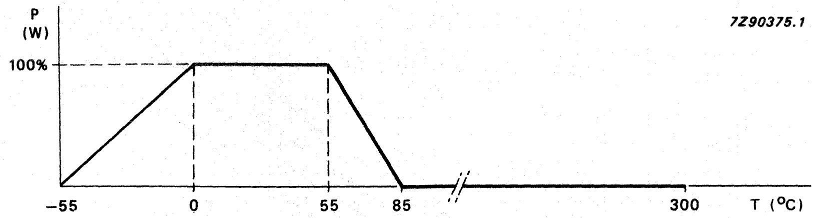


Fig.2 Derating curve.

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	−40 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = −0.2%
C2 4.14	68-2-14	rapid change of temperature	−40 °C to 125 °C 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/75}$ value of 3965 K.

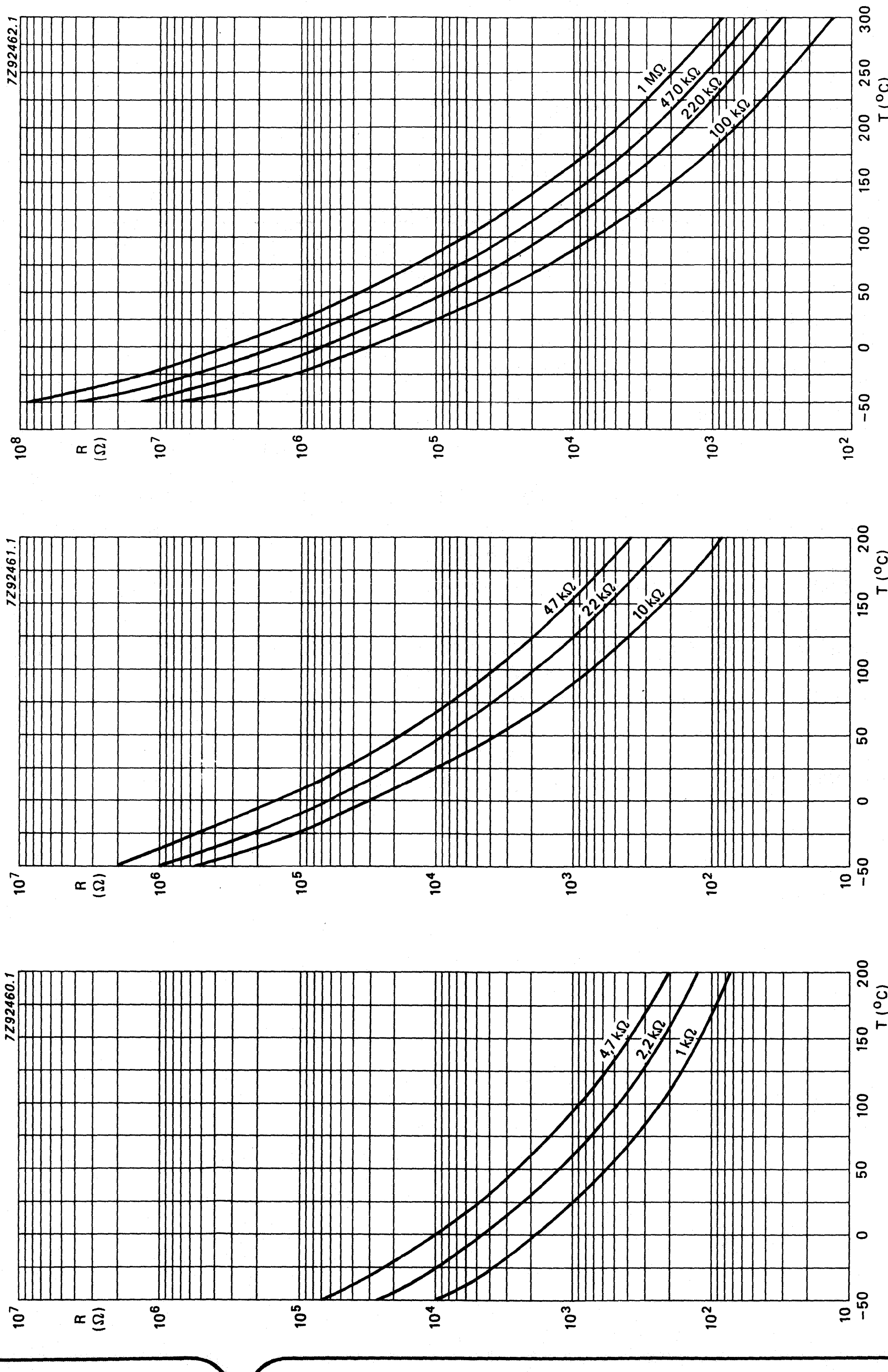


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS

miniature bead

Features

- Very small
- Very quick response to changes in temperature
- Very high long term stability
- High temperature uses

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at 25 °C	1 kΩ to 1 MΩ	
Tolerance on R_{25} value	± 5%, ± 10%	←
$B_{25/85}$ value	2075 to 4100 K	
Tolerance on $B_{25/85}$ value	± 5%	←
Response time	0.5 s approx.	←
Operating temperature range at zero power	−55 to 200 °C	

APPLICATION

Temperature measurement, level and flow sensing.

DESCRIPTION

Bead thermistor with negative temperature coefficient, with two solid platinum-iridium leads in axial or radial configuration.

MECHANICAL DATA

Outlines

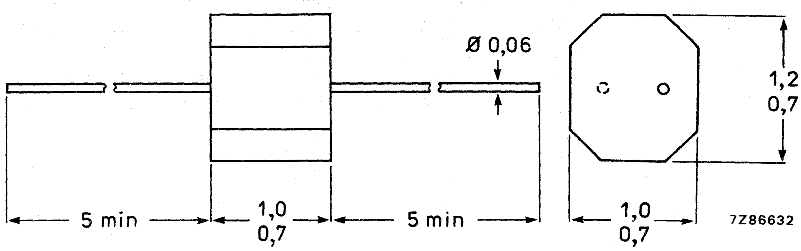


Fig.1
version 2322 633 0....
(axial leads).

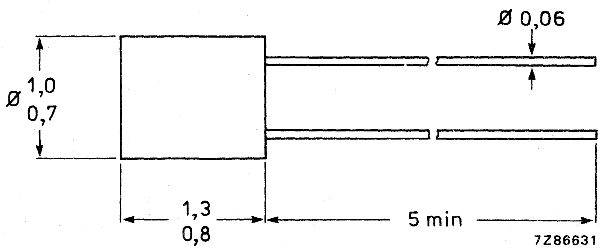


Fig.2
version 2322 633 1....
(radial leads).

Marking

none.

Mounting

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

Mass

5 mg. approximately.

Inflammability

Uninflammable.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Table 1 Electrical data

catalogue number				R_{25}	temperature coefficient at 25 °C	$B_{25/85}$-value ± 5%
2322 633 0.... axial leads		2322 633 1.... radial leads				
tol. ± 5%	tol. ± 10%	tol. ± 5%	tol. ± 10%	kΩ	%/K	K
3102	2102	3102	2102	1	−2.3	2075
3222	2222	3222	2222	2.2	−2.6	2285
3472	2472	3472	2472	4.7	−2.8	2485
3103	2103	3103	2103	10	−4.2	3750
3223	2223	3223	2223	22	−4.0	3560
3473	2473	3473	2473	47	−4.2	3750
3104	2104	3104	2104	100	−4.4	3900
3224	2224	3224	2224	220	−4.5	3860
3474	2474	3474	2474	470	−4.5	3950
3105	2105	3105	2105	1000	−4.6	4100

→ Response time (see Note 1) 0.5 s approx.

Operating temperature range, at zero power −55 to + 200 °C

→ **Note:**

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air, to 85 °C in oil.

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	−40 °C, 1000 hours	ΔR/R ≤ 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = −0.2%
C2 4.14	68-2-14	rapid change of temperature	−40 °C to 125 °C 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/85}$ value of 3797 K.

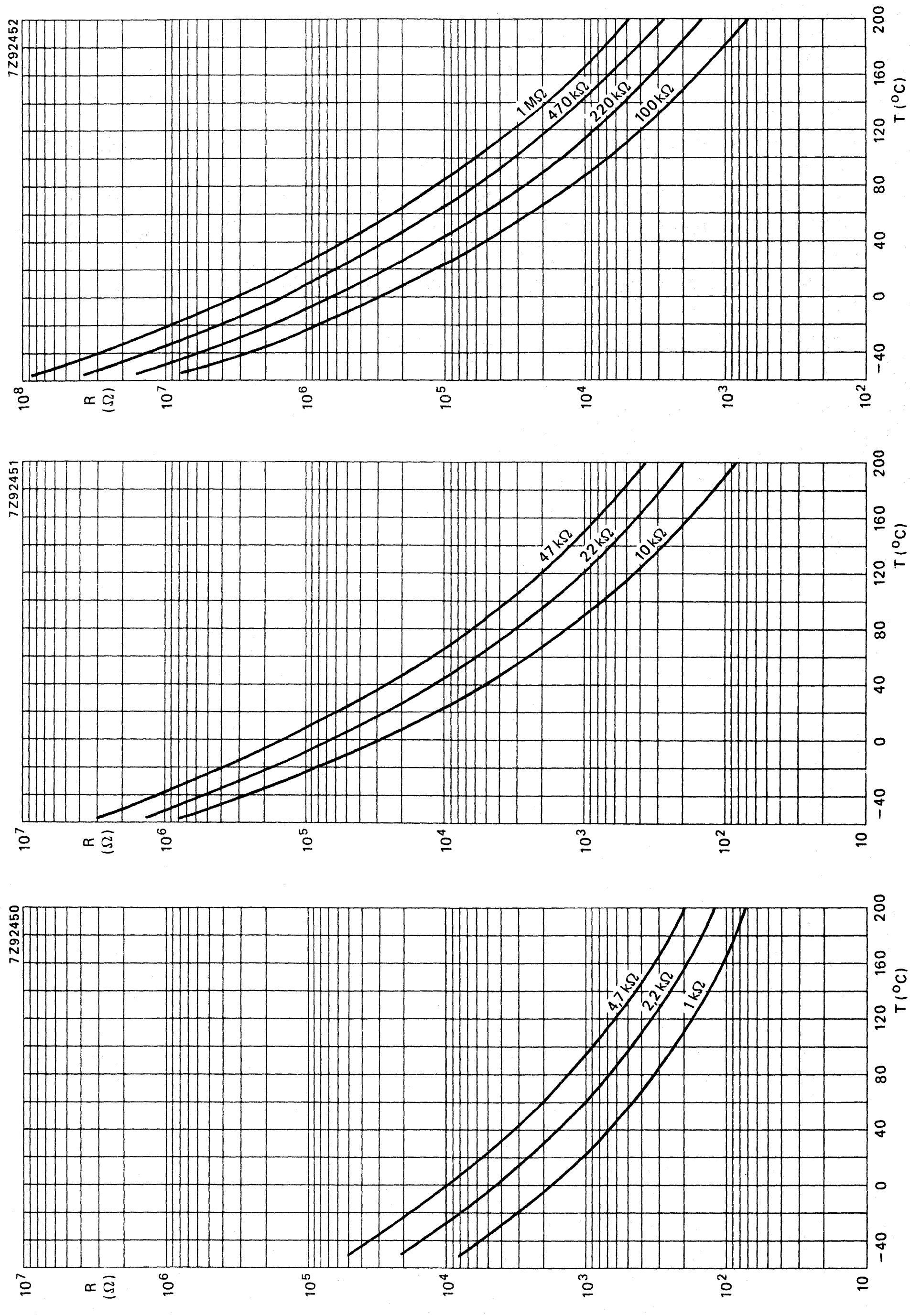


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS

glass encapsulated miniature bead

Features

- Small diameter
- Quick response to changes in temperature
- High stability over long time periods
- High temperature operation
- Resistant to aggressive environments

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at 25 °C	1 kΩ to 1 MΩ
Tolerance on R_{25} value	± 5%, ± 10%
$B_{25/85}$ value	2075 to 4100 K
Tolerance on $B_{25/85}$ value	± 5%
Response time	6 s approx.
Thermal time constant	5.5 s approx.
Operating temperature range	
at zero power	−55 to 200 °C
at maximum power	0 to 55 °C

APPLICATION

Temperature measurements

DESCRIPTION

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

MECHANICAL DATA

Outlines

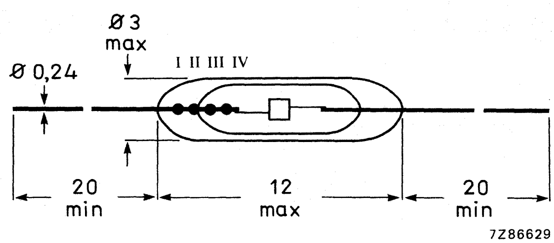


Fig.1 Component outline.

Marking

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

Mass

0.1 g approximately.

Mounting

In any position by soldering.

Soldering

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

Inflammability

Uninflammable.

Impact

free fall	100 mm

Robustness of terminations

Tensile strength	1.0 N
Bending	0.5 N
Torsion	3 times
Resistance to solvents:	in accordance with IEC 68-2-45, resistant to R113 at T_{amb}

Packaging

100 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured in accordance with IEC publication 539.

Maximum dissipation at +55 °C	60 mW
Dissipation factor	0.5 mW/K approx.
Thermal time constant	5.5 s approx.
→ Response time (see note 1)	6 s approx.
Operating temperature range (Fig.2)	
at zero power	−55 to +200 °C
at maximum power	0 to +55 °C
Dielectric withstanding voltage (RMS)	
between terminals and glass envelope	min. 1500 V
Insulation resistance between terminals	
and glass envelope at 100 V (DC)	min. 100 MΩ

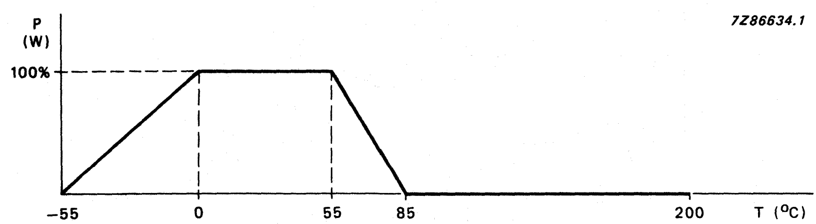


Fig.2 Derating curve.

Note

1. Response time in silicone oil MS 200/50. The response time in silicone oil is the time necessary to change of 63.2% of the total difference between the initial and the final body temperature, when subjected to a step function change in ambient temperature. Step change: initial temperature: air at 25 °C; final temperature: oil (MS 200/50) at 85 °C.

Table 1 Catalogue number 2322 633 2 ....

suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code*		
tol. ± 5%	tol. ± 10%	kΩ	K	%/K	I	II	III
3102	2102	1	2075	–2.3	brown	black	red
3222	2222	2.2	2285	–2.6	red	red	red
3472	2472	4.7	2485	–2.8	yellow	violet	red
3103	2103	10	3750	–4.2	brown	black	orange
3223	2223	22	3560	–4.0	red	red	orange
3473	2473	47	3750	–4.2	yellow	violet	orange
3104	2104	100	3900	–4.4	brown	black	yellow
3224	2224	220	3860	–4.3	red	red	yellow
3474	2474	470	3950	–4.5	yellow	violet	yellow
3105	2105	1000	4100	–4.6	brown	black	green

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

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	–40 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = –0.2%
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C, 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/85}$ value of 3797 K.

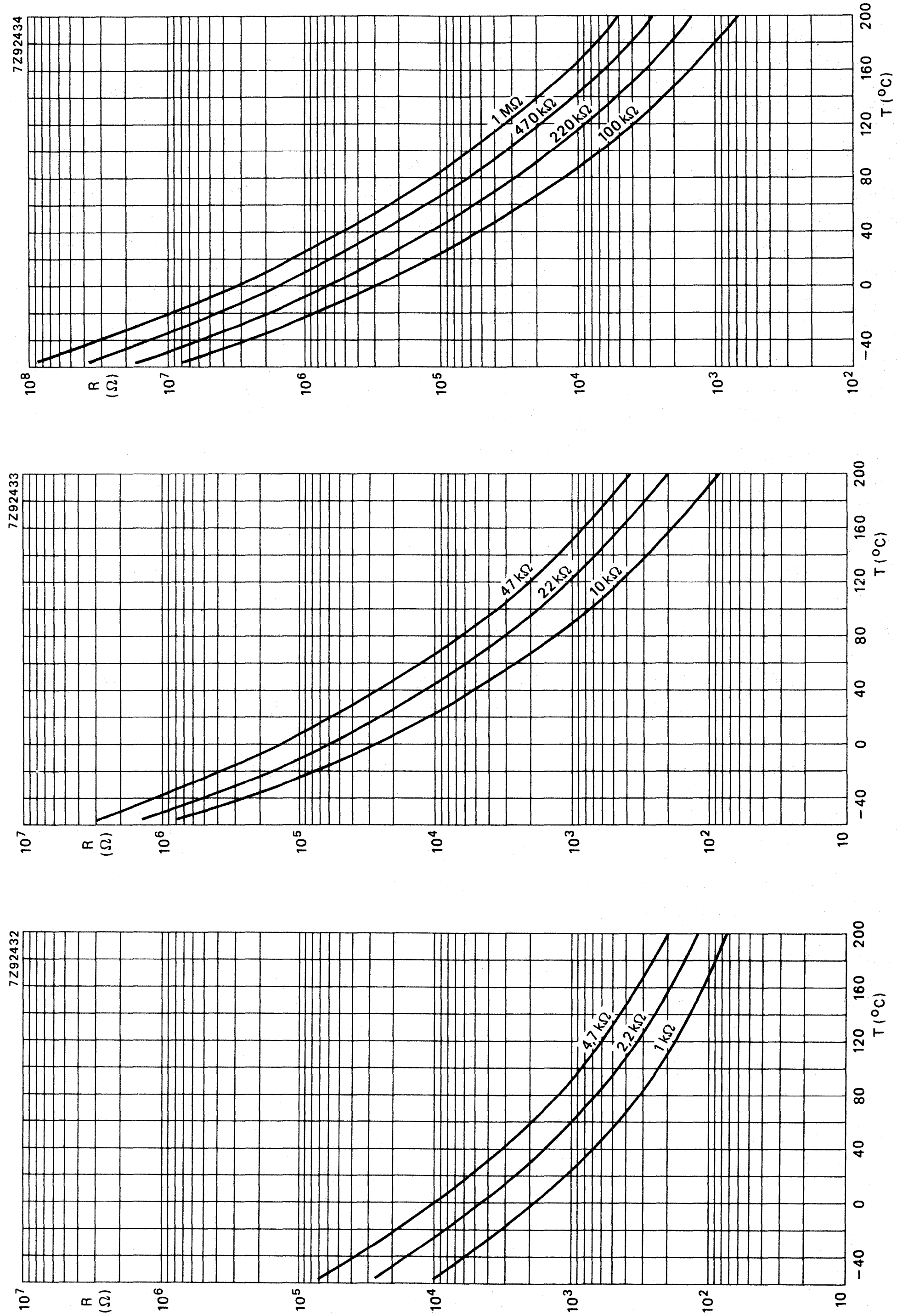


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS
SOD27 range

Features

- Small diameter
- Quick response to changes in temperature
- High long term stability
- High temperature
- Resistant to aggressive environments

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Type	2322 633	72224	73224
Resistance at 25 °C	220 kΩ	± 10%	± 5%
Response time		0.75	s approx.
Operating temperature range			
at zero power		25 to 300	°C
at maximum power		25 to 55	°C

APPLICATION

For high temperature measurement and control in domestic appliances and industrial process control equipment.

DESCRIPTION

These thermistors have a negative temperature coefficient and are mounted in a glass envelope (SOD27). They have two nickel plated copper clad iron connecting leads.

MECHANICAL DATA

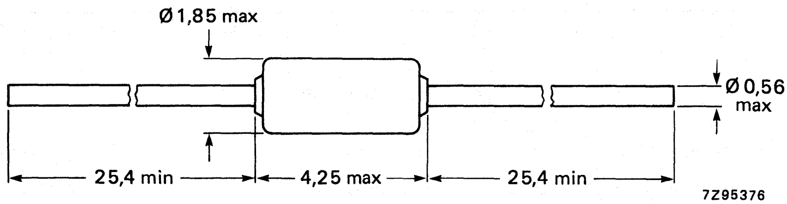


Fig.1 Component outline; SOD27.

Marking	: none
Mass	: 0.14 g approximately
Mounting	: in any position by soldering
Resistance to solvents	: according to IEC 68-2-45

Robustness of terminations

tensile strength	10 N
bending	5 N
torsion	3 times

Soldering

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

For operating temperatures up to 300 °C spot welding is preferred.

Impact

Free fall — 100 mm

Inflammability — not inflammable, according to IEC 695-2-2

Packaging

500 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance at 25 °C	
type 2322 633 72224	220 kΩ ± 10%
type 2322 633 73224	220 kΩ ± 5%
$B_{25/85}$ value	3797 K ± 3%
Maximum dissipation	100 mW
→ Response time (see note 1)	0.75 s approx.
Operating temperature range	
at zero power	25 to 300 °C
at maximum power	25 to 55 °C
Derating	See Fig.2.

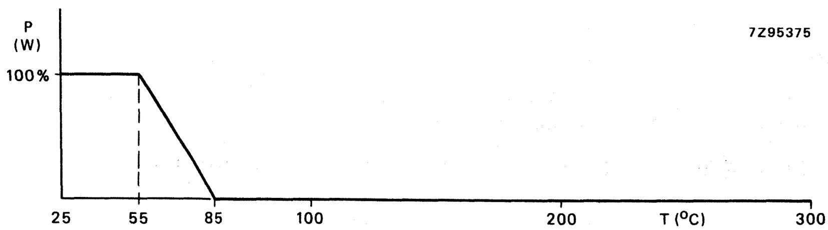


Fig. 2 Derating curve.

Dry heat at 300 °C, steady state	max. 1000 hours
Rapid change of temperature, 30 s at 25 °C/15 s at 300 °C	50 000 cycles

For resistance values at intermediate temperatures, see Table 1

→ **Note:**

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air, to 85 °C in oil.

Table 1 Resistance values at intermediate temperatures

temperature	resistance	2322 633 72224 tolerance on R		2322 633 73224 tolerance on R		temp. coefficient
°C	Ω	+ %	– %	+ %	– %	%/K
25	220 000	10,00	10,00	5,00	5,00	–4,12
30	179 500	10,61	10,61	5,61	5,61	–4,02
40	121 300	11,80	11,76	6,80	6,76	–3,81
50	83 630	12,94	12,58	7,94	7,58	–3,63
60	58 710	14,04	13,88	9,04	8,88	–3,45
70	41 920	15,10	14,84	10,10	9,84	–3,29
80	30 410	16,12	15,75	11,12	10,75	–3,13
90	22 390	17,10	16,65	12,10	11,65	–2,99
100	16 720	18,01	17,41	13,01	12,41	–2,87
110	12 630	18,95	18,23	13,95	13,23	–2,74
120	9 663	19,83	18,95	14,83	13,95	–2,62
130	7 478	20,68	19,64	15,68	14,64	–2,51
140	5 851	21,50	20,32	16,50	15,32	–2,40
150	4 625	22,28	20,94	17,28	15,94	–2,30
160	3 691	23,06	21,54	18,06	16,54	–2,21
170	2 973	23,79	22,14	18,79	17,14	–2,12
180	2 415	24,49	22,67	19,49	17,67	–2,04
190	1 978	25,17	23,20	20,17	18,20	–1,96
200	1 632	25,87	23,66	20,87	18,66	–1,90
210	1 355	26,46	24,17	21,46	19,17	–1,83
220	1 132	27,14	24,60	22,14	19,60	–1,76
230	952	27,70	25,07	22,70	20,07	–1,70
240	806	28,32	25,48	23,32	20,48	–1,64
250	686	28,90	25,90	23,90	20,90	–1,58
260	587	29,45	26,42	24,45	21,42	–1,53
270	506	29,99	26,67	24,99	21,67	–1,47
280	437	30,50	27,03	25,50	22,03	–1,43
290	380	31,02	27,36	26,02	22,36	–1,38
300	332	31,50	27,72	26,50	22,72	–1,33

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	–40 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = –0.2%
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C, 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/85}$ value of 3797 K.

NTC THERMISTOR
medium temperature

Features
- very small
- very quick response to temperature changes
- high accuracy at body temperature

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at 37 °C	420 kΩ
Tolerance on R_{37} value	± 3.6%
Response time	approx. 0.5 s
Operating temperature range at zero power	−25 to + 125 °C

APPLICATION
This thermistor has been specifically designed for use in medical applications.

MECHANICAL DATA
Dimensions in mm

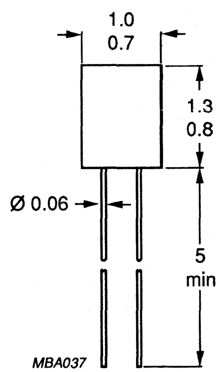


Fig.1 Component outline.

Marking: none
Mass : 3.5 mg approx.

PACKING
The thermistors are packed in carboard boxes, each box containing 100 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Resistance at 37 °C	420 kΩ
Tolerance on R_{37} value	± 3.6%
Resistance at 42 °C	343.5 kΩ
Tolerance on R_{42} value	± 4.4%
Response time	approx. 0.5 s
Operating temperature range at zero power	−25 to + 125 °C

NTC THERMISTOR

low, medium, and high temperature

TEMPERATURE SENSING AND CONTROL

Features

- excellent accuracy between 25 ^{o}C and 85 ^{o}C
- high stability

QUICK REFERENCE DATA

Resistance at 25 ^{o}C	4.7 Ω to 100 kΩ
Tolerance on R_{25} value	± 0.5 ^{o}C
Resistance at 85 ^{o}C	502.9 Ω to 9.498 kΩ
Tolerance on R_{85} value	0.5 ^{o}C
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to + 125 ^{o}C
at maximum power	0 to + 55 ^{o}C

MECHANICAL DATA

Dimensions in mm

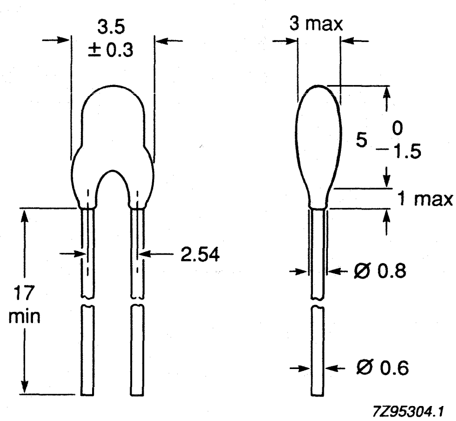


Fig.1 Component outline.

Marking: grey lacquered body

Mass : 0.22 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box containing 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance at 25 °C (see note 1)	4.7 Ω to 100 kΩ
Tolerance on R_{25} value	± 0.5 °C
Resistance at 85 °C	502.9 Ω to 9.498 kΩ
Tolerance on R_{85} value	0.5 °C
Response time (see note 2) (for information only)	1.2 s
Rated dissipation	250 mW
Dissipation factor (for information only)	7 mW/K
Thermal time constant (for information only)	11 s
Operating temperature range	
at zero power	−40 to + 125 °C
at maximum power	0 to + 55 °C

Table 1 Electrical data

catalogue number	R_{25} value ± 0.5 °C kΩ	R_{85} value ± 0.5 °C Ω	$B_{25/85}$ value (typical) K	temperature coefficient at 25 °C %/K
2322 640 10472	4.7	502.9	3977	−4.37
2322 640 10103	10	1070	3977	−4.37
2322 640 10473	47	4721	4090	−4.46
2322 640 10104	100	9498	4190	−4.57

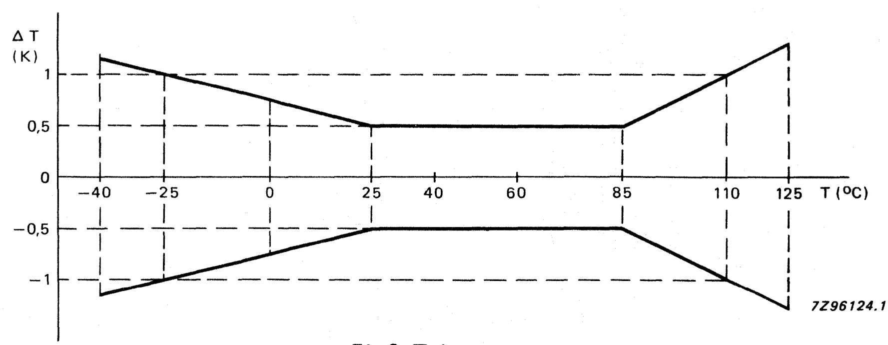


Fig.2 Tolerance curve.

Notes

1. For values of nominal resistance value and tolerance at intermediate temperatures, please refer to Table 2.
2. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

Table 2 Resistance values at intermediate temperatures

temperature °C	2322 640 10472 kΩ	2322 640 10103 kΩ	2322 640 10473 kΩ	2322 640 10104 kΩ
−40	154.3	328.4	1586	3665
−35	111.7	237.7	1149	2635
−30	81.72	173.9	840.7	1914
−25	60.40	128.5	621	1404
−20	45.07	95.89	463	1040
−15	33.95	72.23	348.3	776.9
−10	25.80	54.89	264.1	585.5
−5	19.77	42.07	202	444.9
0	15.28	32.51	155.6	340.7
5	11.90	25.31	120.8	262.9
10	9.334	19.86	94.47	204.4
15	7.374	15.69	74.37	160.0
20	5.87	12.49	58.93	126.1
25	4.7	10.00	47.00	100.0
30	3.788	8.06	37.71	79.82
35	3.072	6.536	30.44	64.10
40	2.506	5.331	24.70	51.76
45	2.055	4.373	20.16	42.04
50	1.695	3.606	16.54	34.32
55	1.405	2.989	13.64	28.17
60	1.17	2.49	11.30	23.23
65	0.98	2.085	9.407	19.25
70	0.8239	1.753	7.867	16.03
75	0.6961	1.481	6.608	13.40
80	0.5903	1.256	5.574	11.26
85	0.5029	1.07	4.721	9.498
90	0.4303	0.9155	4.014	8.043
95	0.3695	0.7861	3.427	6.838
100	0.3184	0.6775	2.936	5.836
105	0.2754	0.586	2.524	4.999
110	0.2390	0.5086	2.178	4.297
115	0.2082	0.4429	1.885	3.706
120	0.1819	0.387	1.637	3.207
125	0.1594	0.3392	1.427	2.784

NTC THERMISTORS

accuracy line
(low heat loss accuracy line)

Features

TEMPERATURE SENSING AND CONTROL

- Accurate over a wide temperature range (tolerance on B-value between 3% and 0.75%)
- Good stability
- Excellent price/performance ratio
- Flexible leads
- Low heat conductivity through leads (0.4 mm diameter Ni leads)

QUICK REFERENCE DATA

Resistance at 25 °C	2.7 kΩ to 470 kΩ
Tolerance on R_{25} value	± 5%, ± 3%, ± 2%, ± 1%
Tolerance on $B_{25/85}$ value	± 3% to ± 0.75%
Response time (for information only)	1.7 s
Operating temperature range	
at zero power (continuously)	−40 to 125 °C
(for short periods)	up to 150 °C
at maximum power (100 mW)	0 to 55 °C

APPLICATION

Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two Nickel wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

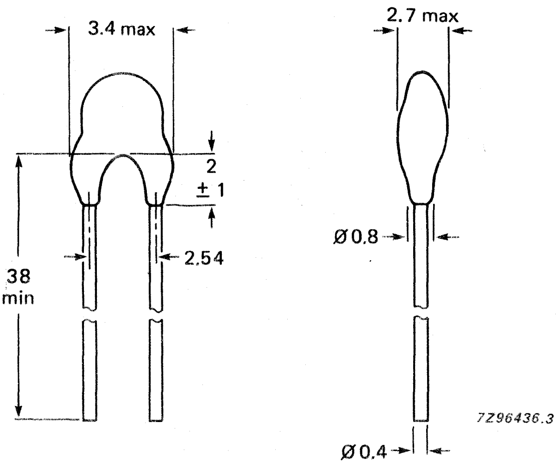


Fig.1 Component outline.

MECHANICAL DATA (continued)

Marking: The thermistors have a black coloured body

Mass: 0.11 grams approx.

Mounting: By soldering (in any position)

Robustness of terminations:

Tensile strength	10 N
Bending (leads not allowed to break or become loose)	5 N

Soldering:

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

Resistance to solvents:

In accordance with IEC 68-2-45, resistant to R113 at ambient temperature

Impact:

Free fall	1 m

Shock: 490 m/s for 11 ms, half sine-wave

Inflammability:

The thermistors meet the requirements of IEC Publication 695-2-2 (1980, needle flame test)

PACKING

The thermistors are packed in cardboard boxes; the smallest packing quantity is 500 thermistors.

ELECTRICAL DATA

Unless otherwise stated, the thermistors have been measured in accordance with IEC Publication 539.

Standard selection tolerance on R_{25}	± 5%, ± 3%, ± 2% and ± 1%
Stability	in accordance with CECC 43 000 and IEC; see Table 2
Climatic category	40/125/56
Rated dissipation	100 mW
Dissipation factor (for information only)	2.2 mW/K
Response time (for information only)	1.7 s (see note 1)
Thermal time constant (for information only)	13 s
Operating temperature range	
at zero power (continuously)	−40 to 125 °C
(for short periods)	up to 150 °C (note 2)
at maximum power (100 mW)	0 to 55 °C

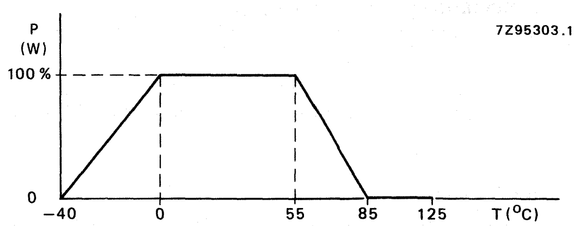


Fig.2 Derating curve.

Table 1 Electrical data

R_{25} value kΩ	$B_{25/85}$ value	catalogue number 2322 640 5. . . . . R_{25} ± 5%	catalogue number 2322 640 5. . . . . R_{25} ± 3%	catalogue number 2322 640 5. . . . . R_{25} ± 2%	catalogue number 2322 640 5. . . . . R_{25} ± 1%
2.7	3977 K± 0.75%	. 3272	. 6272	. 4272	. 5272
4.7	3977 K± 0.75%	. 3472	. 6472	. 4472	. 5472
10	3977 K± 0.75%	. 3103	. 6103	. 4103	. 5103
47	3977 K± 1.5%	. 3473	. 6473	. 4473	
100	4190 K± 2%	. 3104	. 6104	. 4104	
470	4570 K± 3%	. 3474	. 6474	. 4474	

Notes

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.
2. Valid for all types with the exception of 2322 640 5.474.

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical) (note 1)
D3 4.20.1		endurance	25 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.1\%$
	68-2-1	endurance	–40 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.15\%$
	539-gen	endurance	100 mW, 55 °C, 1000 hours	$\Delta R/R < 3\%$	$\Delta R/R = 0.5\%$
	68-2-2	dry heat, steady state	125 °C, 1000 hours	$\Delta R/R < 3\%$	$\Delta R/R = 0.1\%$
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	$\Delta R/R < 3\%$	$\Delta R/R = -0.2\%$
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C 50 cycles	$\Delta R/R < 2\%$	$\Delta R/R = 0.1\%$

Note to Table 2

1. Typical drift is based on sample products with a $B_{25/85}$ value of 3977 K and a $B_{25/75}$ value of 3965 K.

R_T values and tolerance on R_T values

These thermistors have a narrow tolerance on the B value, the result of which provides a very small tolerance on the nominal resistance value over a wide temperature range. The same table describing R as a function of T with steps of 5 °C as published for the series 2322 640 6. . . . range is relevant here. Also the 'Steinhart and Hart' equation of the above range can be used here to calculate intermediate resistance values. The relevant part of the table is that containing the R_{25} values and $B_{25/85}$ values of the 2322 640 5. . . . range.

SUPERSEDES DATA OF SEPTEMBER 1986

NTC THERMISTORS

accuracy line
(extended accuracy line)

Features

- Accurate over wide temperature range
- High stability
- Excellent price/performance ratio

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

QUICK REFERENCE DATA

Resistance value at 25 °C	2.7 kΩ to 470 kΩ
Tolerance on R_{25} value	± 2%, ± 3%, ± 5%, ± 10%
Tolerance on $B_{25/85}$ value	± 3% to ± 0.75%
Response time	1.2 s
Operating temperature range	
at zero power (continuously)	–40 to 125 °C
(for short periods) (note 1)	up to 150 °C
at maximum power (250 mW)	0 to 55 °C

APPLICATION

Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two Nickel wires. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

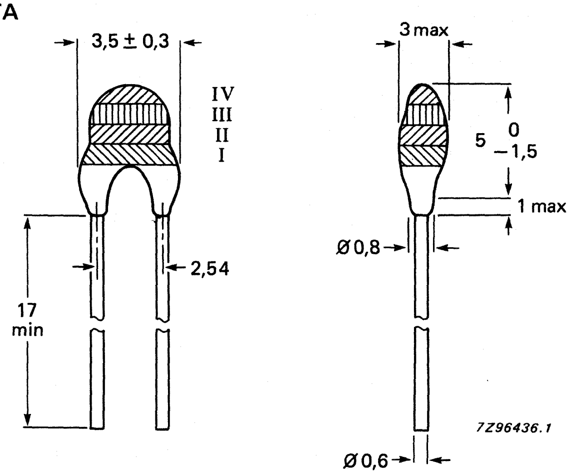


Fig.1 Component outline.

Note

1. For part of product range only; see Table 1 for details.

MECHANICAL DATA (continued)

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

Mass: 0.22 g approx.

Mounting: in any position by soldering.

Robustness of terminations	
Tensile strength	10 N
Bending (leads not allowed to break or become loose)	5 N
Soldering	
Solderability	max. 240 °C, max. 4 s
Resistance to heat	max. 265 °C, max. 11 s

Resistance to solvents
Resistant to R113 at ambient temperatures in accordance with IEC Publication 68-2-45.

Impact	
Free fall	1 m

Shock: 490 m/s, 11 ms, half sine-wave

Inflammability
The thermistors meet the requirements of IEC Publication 695-2-2 (1980, needle flame test)

PACKING

The thermistors are packed in cardboard boxes, the smallest packing quanity is 500 thermistors. Products can be supplied on tape on special request.

ELECTRICAL DATA

Unless otherwise stated, the thermistors have been measured in accordance with IEC Publication 539 (see also Table 1).

Standard selection tolerance on R_{25}	± 2%, ± 3%, ± 5%, ± 10%
Stability	in accordance with CECC 43 000 and IEC; see Table 2
Climatic category	40/125/56
Rated dissipation	250 mW
Dissipation factor (for information only)	7 mW/K
Response time (for information only)	1.2 s (note 1)
Thermal time constant (for information only)	11 s
Operating temperature range	
at zero power (continuously)	–40 to 125 °C
(for short periods)	up to 150 °C (note 2)
at maximum power (250 mW)	0 to 55 °C

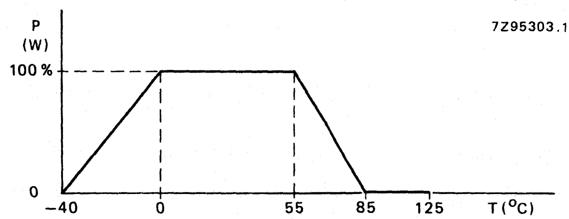


Fig.2 Derating curve.

Notes

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.
2. Valid for part of product range only, see Table 1.

Table 1 Electrical data

R_{25} value kΩ	$B_{25/85}$ value	catalogue number 2322 640 6 . . . . R_{25} ± 2%	catalogue number 2322 640 6 . . . . R_{25} ± 3%	catalogue number 2322 640 6 . . . . R_{25} ± 5%	catalogue number 2322 640 6 . . . . R_{25} ± 10%	colour code band I (note 2)	colour code band II (note 2)	colour code band III (note 2)
2.7 (note 1)	3977 K ± 0.75%	. 4272	. 6272	. 3272	. 2272	red	violet	red
3.3 (note 1)	3977 K ± 0.75%	. 4332	. 6332	. 3332	. 2332	orange	orange	red
4.7 (note 1)	3977 K ± 0.75%	. 4472	. 6472	. 3472	. 2472	yellow	violet	red
6.8 (note 1)	3977 K ± 0.75%	. 4682	. 6682	. 3682	. 2682	blue	grey	red
10 (note 1)	3977 K ± 0.75%	. 4103	. 6103	. 3101	. 2103	brown	black	orange
12	3740 K ± 3%	. 4123	. 6123	. 3123	. 2123	brown	red	orange
15	3740 K ± 3%	. 4153	. 6153	. 3153	. 2153	brown	green	orange
22	3740 K ± 3%	. 4223	. 6223	. 3223	. 2223	red	red	red
33 (note 1)	4090 K ± 1.5%	. 4333	. 6333	. 3333	. 2333	orange	orange	orange
47 (note 1)	4090 K ± 1.5%	. 4473	. 6473	. 3473	. 2473	yellow	violet	orange
68 (note 1)	4190 K ± 2%	. 4683	. 6683	. 3683	. 2683	blue	grey	orange
100 (note 1)	4190 K ± 2%	. 4104	. 6104	. 3104	. 2104	brown	black	yellow
150	4370 K ± 3%	. 4154	. 6154	. 3154	. 2154	brown	green	yellow
220	4370 K ± 3%	. 4224	. 6224	. 3224	. 2224	red	red	yellow
330	4570 K ± 3%	. 4334	. 6334	. 3334	. 2334	orange	orange	yellow
470	4570 K ± 3%	. 4474	. 6474	. 3474	. 2474	yellow	violet	yellow

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical (note 1)
D3 4.20.1		endurance	25 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.1\%$
	68-2-1	endurance	–40 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.15\%$
	539-gen	endurance	250 mW, 55 °C, 1000 hours	$\Delta R/R < 3\%$	$\Delta R/R = 0.5\%$
	68-2-2	dry heat, steady state	125 °C, 1000 hours	$\Delta R/R < 3\%$	$\Delta R/R = 0.1\%$
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	$\Delta R/R < 3\%$	$\Delta R/R = -0.2\%$
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C, 50 cycles	$\Delta R/R < 2\%$	$\Delta R/R = 0.1\%$

Notes to Table 1

1. Operating temperature range at zero power is 150 °C max.
2. Dependent upon R_{25} tolerance, the band IV is colour coded as follows:
   For R_{25} ± 2%, band IV is coloured red
   For R_{25} ± 3%, band IV is coloured orange
   For R_{25} ± 5%, band IV is coloured gold
   For R_{25} ± 10%, band IV is coloured silver

Note to Table 2

1. Typical drift is based on sample products with a $B_{25/85}$ value of 3977 K and a $B_{25/75}$ value of 3965 K.

R_T values and tolerance on R_T values

These thermistors have a narrow tolerance on the B value, the result of which provides a very small tolerance on the nominal resistance value over a wide temperature range. For this reason, the usual graphs of R = f(T) are replaced by Table 5 together with a formula with which the characteristics can be calculated with high accuracy.

Formula to determine nominal resistance values

The resistance values at intermediate temperatures can be calculated using the 'Steinhart and Hart' equation:

$$R_T = (R_{25}/R_{ref}) \times e^{\left[\sqrt[3]{(\sqrt{E^2 + D} - E)} - \sqrt[3]{(\sqrt{E^2 + D} - E)}\right]}$$

Table 4 shows a list of different 'E', 'D', and 'R_{ref}' values for different B values. In the Table, the value of 'T' is the temperature in K.

Table 4 Values to be used with 'Steinhart and Hart' formula

B value (K)	E	D	R_{ref} (kΩ)
3977	5766.8 – [5.0541 x 10^6/T]	4.7692 x 10^8	10
3740	3498.5 – [4.1026 x 10^6/T]	2.7574 x 10^8	22
4090	4194.7 – [4.5876 x 10^6/T]	2.8108 x 10^8	47
4190	4169.4 – [5.0802 x 10^6/T]	3.4453 x 10^8	100
4370	4185.0 – [5.2748 x 10^6/T]	3.1658 x 10^8	220
4570	4404.9 – [5.6266 x 10^6/T]	3.1666 x 10^8	470

Determination of the resistance/temperature deviation from the nominal

The complete resistance deviation is obtained by combining the 'R_{25} tolerance' value with the 'resistance deviation due to B tolerance' value.

Let X = R_{25} tolerance
Y = resistance deviation due to B tolerance
Z = complete resistance deviation

Then,

$$Z = \{[1 + (X/100)] \times [1 + (Y/100)] - 1\} \times 100$$

or

$$Z = X + Y \text{ (approximation)}$$

TC = temperature coefficient
ΔT = temperature deviation

so

$$\Delta T = Z/TC$$

Example: (at 0 °C)

Let $X = 5\%$
$Y = 0.89\%$ (see Table 5)
$TC = 5.08\%/K$ (see Table 5)

Then

$$
\begin{aligned}
Z &= \{ [1 + (5/100)] \times [1 + (0.89/100)] - 1 \} \times 100 \\
&= \{ [1 + 0.05] \times [1 + 0.0089] - 1 \} \times 100 \\
&= \{ [1.05 \times 1.0089] - 1 \} \times 100 \\
&= \{ 1.0593 - 1 \} \times 100 \\
&= 0.0593 \times 100 \\
&= 5.93\%
\end{aligned}
$$

or, (by approximation)

$$
\begin{aligned}
Z &= X + Y \\
&= 5 + 0.89 \\
&= 5.89\%
\end{aligned}
$$

$$
\begin{aligned}
\Delta T &= Z/TC \\
&= 5.93/5.08 \\
&= 1.167\ (1.17)
\end{aligned}
$$

So, a NTC having a R_{25} value = 10 kΩ has a value of 32.51 kΩ between ± 1.17 °C.

Table 5 Resistance values at intermediate temperatures

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)				
°C		%	%/K	6.272	6.332	6.472	6.682	6.103
−40	32.84	2.64	6.57	88.67	108.4	154.3	223.3	328.4
−35	23.77	2.40	6.36	64.18	78.44	111.7	161.6	237.7
−30	17.39	2.16	6.15	46.95	57.39	81.72	118.3	173.9
−25	12.85	1.93	5.95	34.70	42.41	60.40	87.38	128.5
−20	9.589	1.71	5.76	25.89	31.64	45.07	65.21	95.89
−15	7.223	1.49	5.58	19.50	23.84	33.95	49.12	72.23
−10	5.489	1.29	5.40	14.82	18.11	25.80	37.33	54.89
−5	4.207	1.08	5.24	11.36	13.88	19.77	28.61	42.07
0	3.251	0.89	5.08	8.778	10.73	15.28	22.11	32.51
5	2.531	0.70	4.92	6.834	8.352	11.90	17.21	25.31
10	1.986	0.52	4.78	5.362	6.554	9.334	13.50	19.86
15	1.569	0.34	4.64	4.236	5.178	7.374	10.67	15.69
20	1.249	0.17	4.50	3.372	4.122	5.870	8.493	12.49
25	1.000	0.00	4.37	2.700	3.300	4.700	6.800	10.00
30	0.8060	0.16	4.25	2.176	2.660	3.788	5.481	8.060
35	0.6536	0.32	4.13	1.765	2.157	3.072	4.444	6.536
40	0.5331	0.47	4.02	1.439	1.759	2.506	3.625	5.331
45	0.4373	0.62	3.91	1.181	1.443	2.055	2.973	4.373
50	0.3606	0.77	3.80	0.9736	1.190	1.695	2.452	3.606
55	0.2989	0.91	3.70	0.8070	0.9864	1.405	2.033	2.989
60	0.2490	1.05	3.60	0.6723	0.8217	1.170	1.693	2.490
65	0.2085	1.18	3.51	0.5630	0.6881	0.9800	1.418	2.085
70	0.1753	1.31	3.42	0.4733	0.5785	0.8239	1.192	1.753
75	0.1481	1.44	3.33	0.3999	0.4887	0.6961	1.007	1.481
80	0.1256	1.57	3.25	0.3391	0.4145	0.5903	0.8541	1.256
85	0.1070	1.69	3.16	0.2889	0.3531	0.5029	0.7276	1.070
90	0.09155	1.81	3.09	0.2472	0.3021	0.4303	0.6225	0.9155
95	0.07861	1.93	3.01	0.2122	0.2594	0.3695	0.5345	0.7861
100	0.06775	2.04	2.94	0.1829	0.2236	0.3184	0.4607	0.6775
105	0.05860	2.15	2.87	0.1582	0.1934	0.2754	0.3985	0.5860
110	0.05086	2.26	2.80	0.1373	0.1678	0.2390	0.3458	0.5086
115	0.04429	2.37	2.73	0,1196	0.1462	0.2082	0.3012	0.4429
120	0.03870	2.47	2.67	0.1045	0.1277	0.1819	0.2632	0.3870
125	0.03392	2.57	2.61	0.0916	0.1119	0.1594	0.2307	0.3392
130	0.02982	2.67	2.55	0.0805	0.0984	0.1402	0.2028	0.2982
135	0.02629	2.77	2.49	0.0710	0.0868	0.1236	0.1788	0.2629
140	0.02324	2.86	2.43	0.0627	0.0767	0.1092	0.1580	0.2324
145	0.02061	2.95	2.38	0.0556	0.0680	0.0969	0.1402	0.2061
150	0.01832	3.05	2.33	0.0495	0.0605	0.0861	0.1246	0.1832

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

Table 5 (continued)

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)		
°C		%	%/K	6.123	6.153	6.223
−40	25.80	10.24	6.09	309.5	386.9	567.5
−35	19.12	9.26	5.89	229.4	286.8	420.6
−30	14.31	8.31	5.70	171.7	214.6	314.8
−25	10.81	7.40	5.52	129.7	162.1	237.8
−20	8.235	6.53	5.35	98.82	123.5	181.2
−15	6.328	5.69	5.19	75.94	94.92	139.2
−10	4.902	4.88	5.03	58.82	73.52	107.8
−5	3.826	4.11	4.88	45.91	57.39	84.17
0	3.009	3.36	4.73	36.10	45.13	66.19
5	2.383	2.64	4.60	28.59	35.74	52.42
10	1.900	1.94	4.46	22.79	28.49	41.79
15	1.524	1.27	4.34	18.29	22.87	33.54
20	1.231	0.63	4.21	14.77	18.46	27.08
25	1.000	0.00	4.10	12.00	15.00	22.00
30	0.8171	0.61	3.98	9.805	12.26	17.98
35	0.6713	1.20	3.88	8.055	10.07	14.77
40	0.5545	1.79	3.77	6.653	8.317	12.20
45	0.4603	2.35	3.67	5.524	6.905	10.13
50	0.3840	2.91	3.57	4.609	5.761	8.449
55	0.3219	3.46	3.48	3.863	4.829	7.083
60	0.2711	3.99	3.39	3.253	4.067	5.964
65	0.2293	4.52	3.30	2.752	3.440	5.045
70	0.1948	5.03	3.22	2.337	2.922	4.285
75	0.1661	5.53	3.14	1.994	2.492	3.655
80	0.1423	6.02	3.06	1.707	2.134	3.130
85	0.1223	6.51	2.99	1.467	1.834	2.690
90	0.1055	6.98	2.92	1.266	1.582	2.321
95	0.09133	7.44	2.85	1.096	1.370	2.009
100	0.07935	7.90	2.78	0.9522	1.190	1.746
105	0.06917	8.34	2.71	0.8300	1.037	1.522
110	0.06048	8.78	2.65	0.7258	0.9072	1.331
115	0.05305	9.21	2.59	0.6366	0.7958	1.167
120	0.04668	9.63	2.53	0.5602	0.7002	1.027
125	0.04119	10.04	2.47	0.4943	0.6179	0.9061

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)	
°C		%	%/K	6.333	6.473
−40	33.74	5.42	6.55	1114	1586
−35	24.44	4.91	6.34	806.7	1149
−30	17.89	4.42	6.15	590.3	840.7
−25	13.21	3.95	5.96	436.1	621
−20	9.852	3.49	5.78	325.1	463
−15	7.41	3.05	5.61	244.5	348.3
−10	5.620	2.62	5.45	185.5	264.1
−5	4.297	2.21	5.29	141.8	202
0	3.311	1.81	5.14	109.3	155.6
5	2.571	1.43	4.99	84.83	120.8
10	2.01	1.05	4.85	66.33	94.47
15	1.582	.69	4.72	52.21	74.37
20	1.254	.34	4.59	41.38	58.93
25	1	0	4.46	33.00	47
30	.8024	.33	4.34	26.48	37.71
35	.6476	.65	4.23	21.37	30.44
40	.5256	.97	4.12	17.35	24.70
45	.4289	1.28	4.01	14.16	20.16
50	.3519	1.58	3.91	11.61	16.54
55	.2902	1.87	3.81	9.575	13.64
60	.2404	2.16	3.71	7.934	11.3
65	.2001	2.44	3.62	6.605	9.407
70	.1674	2.72	3.53	5.524	7.867
75	.1406	2.99	3.44	4.640	6.608
80	.1186	3.25	3.36	3.913	5.574
85	.10045	3.51	3.28	3.315	4.721
90	.08541	3.76	3.2	2.819	4.014
95	.07291	4.01	3.13	2.406	3.427
100	.06246	4.25	3.06	2.061	2.936
105	.05371	4.48	2.98	1.772	2.524
110	.04634	4.72	2.92	1.529	2.178
115	.04012	4.94	2.85	1.324	1.885
120	.03484	5.16	2.79	1.150	1.637
125	.03035	5.38	2.73	1.001	1.427
130	.02653	5.6	2.67	.8754	1.247
135	.02325	5.8	2.61	.7673	1.093
140	.02044	6.01	2.55	.6744	.9605
145	.01801	6.21	2.5	.5944	.8466
150	.01592	6.41	2.44	.5254	.7482

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

Table 5 (continued)

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)	
°C		%	%/K	6.683	6.104
−40	36.65	7.47	6.70	2492	3665
−35	26.35	6.76	6.49	1792	2635
−30	19.14	6.08	6.29	1302	1914
−25	14.04	5.43	6.10	954.7	1404
−20	10.40	4.79	5.92	707.2	1040
−15	7.769	4.19	5.74	528.3	776.9
−10	5.855	3.60	5.57	398.1	585.5
−5	4.449	3.03	5.41	302.5	444.9
0	3.407	2.48	5.26	231.7	340.7
5	2.629	1.95	5.11	178.8	262.9
10	2.044	1.44	4.97	139.0	204.4
15	1.600	0.94	4.83	108.8	160.0
20	1.261	0.46	4.70	85.75	126.1
25	1.000	0.00	4.57	68.00	100.0
30	0.7982	0.45	4.45	54.28	79.82
35	0.6410	0.89	4.35	43.59	64.10
40	0.5176	1.33	4.22	35.20	51.76
45	0.4204	1.75	4.11	28.59	42.04
50	0.3432	2.16	4.00	23.34	34.32
55	0.2817	2.57	3.90	19.16	28.17
60	0.2323	2.96	3.80	15.80	23.23
65	0.1925	3.35	3.71	13.09	19.25
70	0.1603	3.73	3.62	10.90	16.03
75	0.1340	4.10	3.53	9.113	13.40
80	0.1126	4.46	3.45	7.654	11.26
85	0.09498	4.82	3.36	6.458	9.498
90	0.08043	5.17	3.28	5.469	8.043
95	0.06838	5.51	3.21	4.650	6.838
100	0.05836	5.85	3.13	3.969	5.836
105	0.04999	6.18	3.06	3.399	4.999
110	0.04297	6.50	2.99	2.922	4.297
115	0.03706	6.81	2.92	2.520	3.706
120	0.03207	7.12	2.86	2.181	3.207
125	0.02784	7.43	2.80	1.893	2.784

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)	
°C		%	%/K	6.154	6.224
−40	41.38	11.82	6.89	6206	9103
−35	29.47	10.68	6.68	4420	6483
−30	21.20	9.60	6.48	3180	4664
−25	15.41	8.55	6.29	2311	3389
−20	11.30	7.55	6.11	1695	2486
−15	8.363	6.58	5.93	1254	1840
−10	6.243	5.65	5.76	936.5	1374
−5	4.700	4.75	5.60	704.9	1034
0	3.566	3.89	5.44	534.9	784.5
5	2.726	3.05	5.29	409.0	599.8
10	2.100	2.25	5.15	315.0	462.0
15	1.629	1.47	5.01	244.3	358.4
20	1.272	0.72	4.88	190.8	279.9
25	1.000	0.00	4.75	150.0	220.0
30	0.7911	0.71	4.62	118.7	174.0
35	0.6296	1.40	4.51	94.44	138.5
40	0.5040	2.08	4.39	75.60	110.9
45	0.4058	2.74	4.28	60.87	89.27
50	0.3285	3.40	4.17	49.27	72.26
55	0.2673	4.04	4.07	40.09	58.80
60	0.2186	4.67	3.97	32.79	48.09
65	0.1797	5.28	3.87	26.95	39.53
70	0.1484	5.89	3.78	22.25	32.64
75	0.1231	6.49	3.69	18.46	27.08
80	0.1026	7.07	3.60	15.38	22.56
85	0.08582	7.64	3.52	12.87	18.88
90	0.07211	8.21	3.44	10.82	15.86
95	0.06083	8.76	3.36	9.125	13.38
100	0.05152	9.31	3.28	7.728	11.33
105	0.04380	9.84	3.21	6.570	9.635
110	0.03737	10.36	3.14	5.605	8.221
115	0.03199	10.88	3.07	4.799	7.038
120	0.02749	11.39	3.00	4.124	6.048
125	0.02369	11.88	2.94	3.554	5.212

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

Table 5 (continued)

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 640 . . . . . (note 1)	
°C		%	%/K	6.334	6.474
−40	47.68	12.29	7.13	15730	22410
−35	33.56	11.12	6.91	11080	15770
−30	23.87	9.99	6.71	7878	11220
−25	17.15	8.90	6.52	5659	8060
−20	12.44	7.86	6.33	4104	5846
−15	9.103	6.85	6.15	3004	4279
−10	6.721	5.88	5.98	2218	3159
−5	5.005	4.95	5.82	1651	2352
0	3.756	4.05	5.66	1240	1766
5	2.842	3.18	5.50	937.8	1336
10	2.166	2.35	5.36	714.7	1018
15	1.663	1.54	5.22	548.6	781.4
20	1.285	0.76	5.08	424.1	604.0
25	1.000	0.00	4.95	330.0	470.0
30	0.7832	0.74	4.82	258.4	368.1
35	0.6172	1.46	4.70	203.7	290.1
40	0.4893	2.17	4.59	161.5	229.9
45	0.3901	2.86	4.47	128.7	183.3
50	0.3128	3.55	4.36	103.2	147.0
55	0.2521	4.22	4.26	83.21	118.5
60	0.2043	4.88	4.15	67.42	96.03
65	0.1664	5.53	4.06	54.91	78.20
70	0.1362	6.16	3.96	44.93	64.00
75	0.1120	6.79	3.87	36.94	52.62
80	0.09247	7.40	3.78	30.51	43.46
85	0.07671	8.01	3.69	25.31	36.05
90	0.06391	8.60	3.61	21.09	30.04
95	0.05346	9.18	3.53	17.64	25.13
100	0.04490	9.76	3.45	14.82	21.10
105	0.03786	10.32	3.37	12.49	17.79
110	0.03204	10.87	3.30	10.57	15.06
115	0.02722	11.42	3.23	8.983	12.79
120	0.02320	11.95	3.16	7.656	10.90
125	0.01984	12.48	3.09	6.547	9.325

Note

1. Replace dot in catalogue number by one of the following, depending on tolerance on required R_{25} value:
   4 for a tolerance of ± 2%
   6 for a tolerance of ± 3%
   3 for a tolerance of ± 5%
   2 for a tolerance of ± 10%

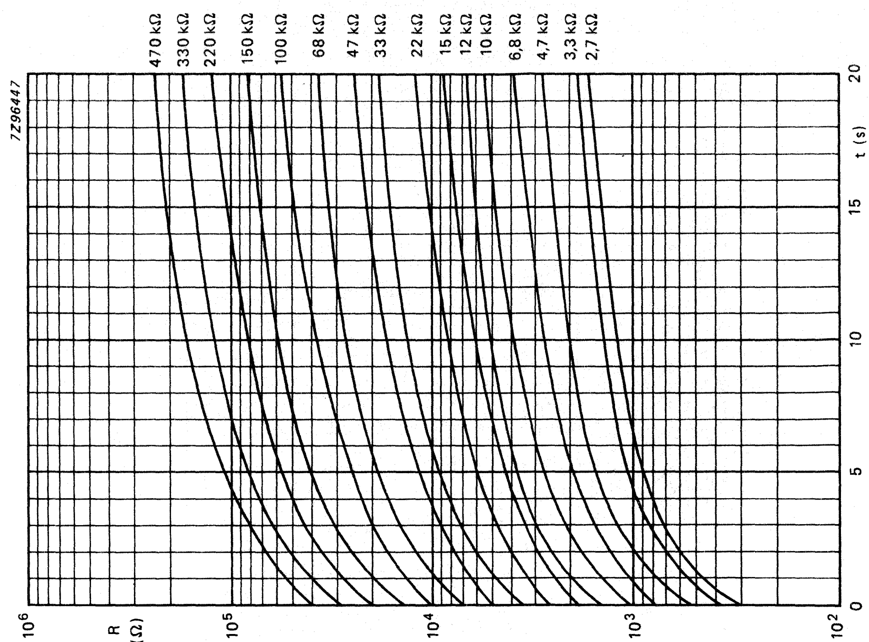


Fig.4 Typical resistance/cooling time characteristics.
T_{amb} = + 25 °C, still air, T_{start} = + 85 °C.

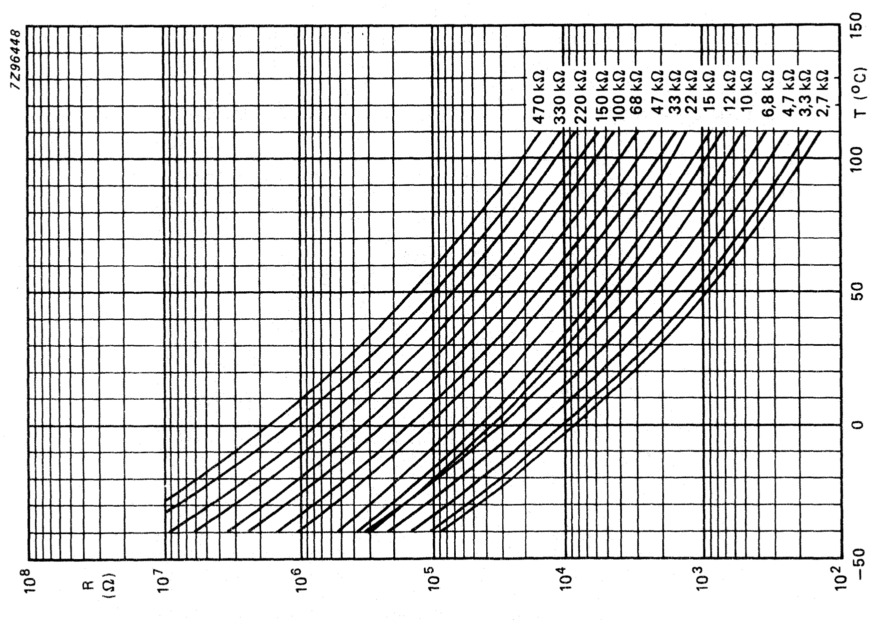


Fig.3 Typical resistance/temperature characteristics.

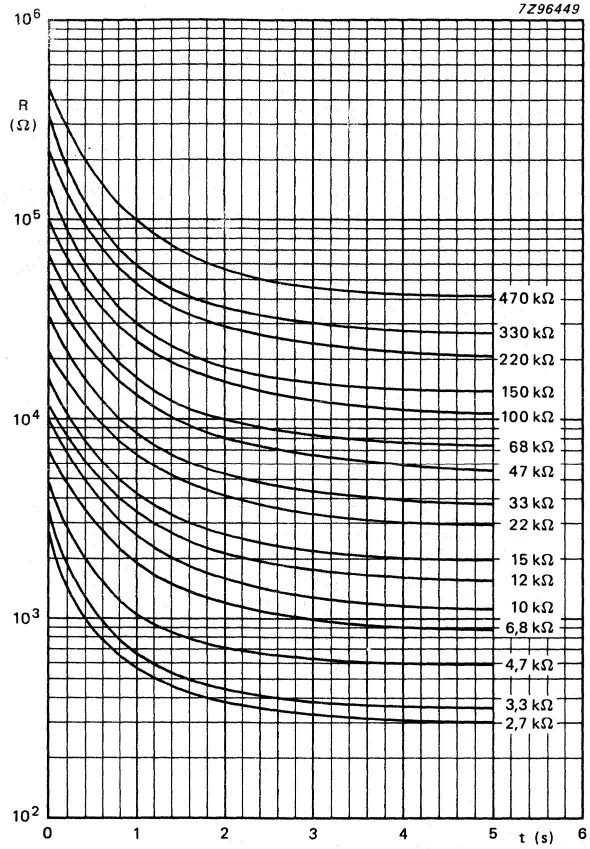


Fig.5 Typical resistance/heating time characteristics, from air of 25 °C to oil of 85 °C.

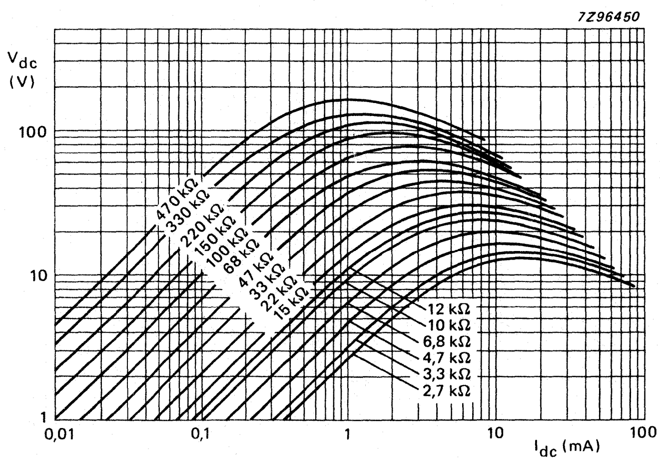


Fig.6 Typical voltage/current characteristics, T_{amb} = + 25 °C, still air.

NTC THERMISTORS
moulded range

Features

- Excellent for surface temperature measurement
- Metal strip for heat conduction and easy mounting
- High accuracy at 100 °C
- Minimum 350 V dielectric withstanding voltage

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

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
Dissipation factor	7	9.5	mW/K
when mounted on a heat-sink	19	27	mW/K
Thermal time constant	19	33	s
when mounted on a heat-sink	10	5	s
Operating temperature range			
at zero power	−10 to + 125	−10 to + 125	°C
at maximum power	0 to + 55	0 to + 55	°C

APPLICATION

For temperature control.

DESCRIPTION

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

MECHANICAL DATA

Outlines

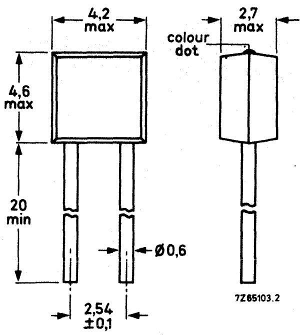


Fig.1 Type 2322 640 90004.

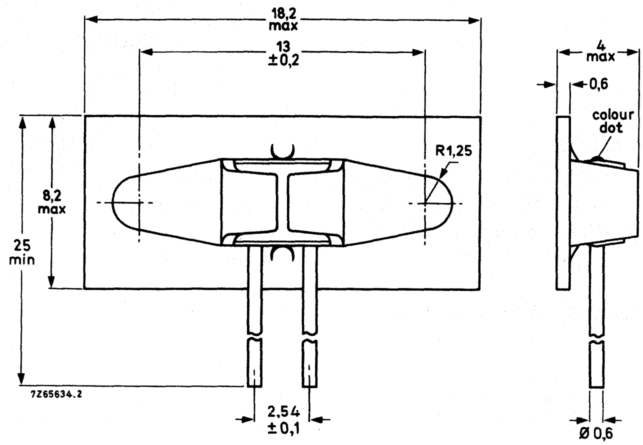


Fig.2 Type 2322 640 98004
with metal strip for mounting.

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

Impact

Free fall	1 m

Inflammability

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

PACKAGING

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

ELECTRICAL DATA

Unless otherwise specified, measured in accordance with IEC publication 539.

Unless otherwise stated, all values are approximate.

	2322 640 90004	2322 640 98004	
Resistance at			
+ 25 °C	12 ± 7%	12 ± 7%	kΩ
+ 100 °C	950 ± 5%	950 ± 5%	Ω
$B_{25/85}$-value	3750	3750	K
Temperature coefficient	−4.2	−4.2	%/K
Maximum dissipation	0.25	0.25	W
Dissipation factor	7	9.5	mW/K
when mounted on a heatsink (see note 1)	19	27	mW/K
Thermal time constant	19	33	s
when mounted on a heatsink (see note 1)	10	5	s
Heat capacity of ceramic (in air)	0.028	0.028	J/K
of complete component (on heatsink)	0.13	0.3	J/K
Response time (see note 2)	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 (RMS) between terminals and coating/strip	min. 350	min. 350	V
Insulation resistance between terminals and coating/strip at 100 V (DC)	min. 100	min. 100	MΩ

Notes

1. Measurements made in still air with the thermistor mounted on a heatsink of 100 cm^2, thickness 1.5 mm, connected between phosphor-bronze wires (ϕ 1.3 mm).
2. The thermistor being transferred from ambient air of + 25 °C to a silicone oil (MS200/50) bath of + 85 °C.

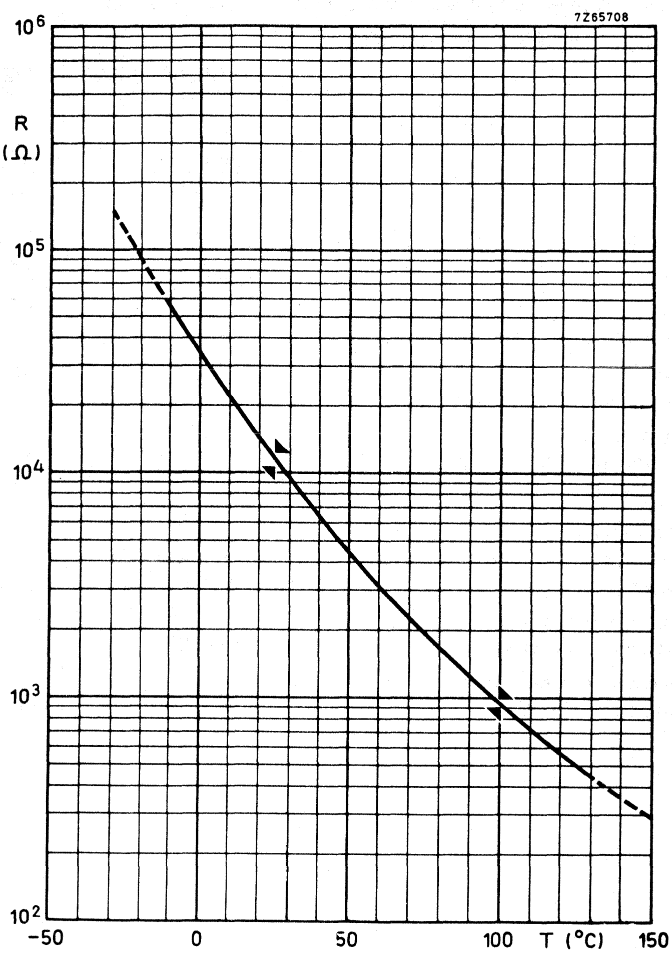


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS

moulded range

Features

- Excellent for surface temperature measurement
- Metal strip for easy mounting
- Will withstand temperatures up to 200 °C
- High accuracy at 200 °C
- Minimum 300 V dielectric withstanding voltage

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

QUICK REFERENCE DATA

	2322 640 90005	2322 640 98005	
Resistance value at			
+ 100 °C	16.7 ± 7%	16.7 ± 7%	kΩ
+ 200 °C	1120 ± 7%	1120 ± 7%	Ω
$B_{25/85}$-value	4300	4300	K
Maximum dissipation	0.25	0.25	W
Dissipation factor	7	9.5	mW/K
when mounted on a heat-sink	17.5	20.5	mW/K
Thermal time constant	19	33	s
when mounted on a heat-sink	12	8.5	s
Operating temperature range			
at zero power	−25 to + 200	−25 to + 200	°C
at maximum power	0 to + 55	0 to + 55	°C

APPLICATION

For high temperature control.

DESCRIPTION

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

MECHANICAL DATA

Outlines

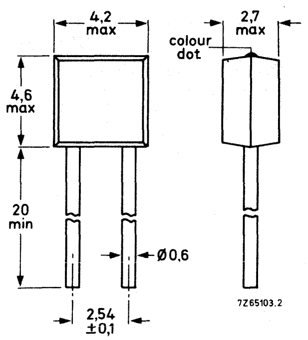


Fig.1 Type 2322 640 98005.

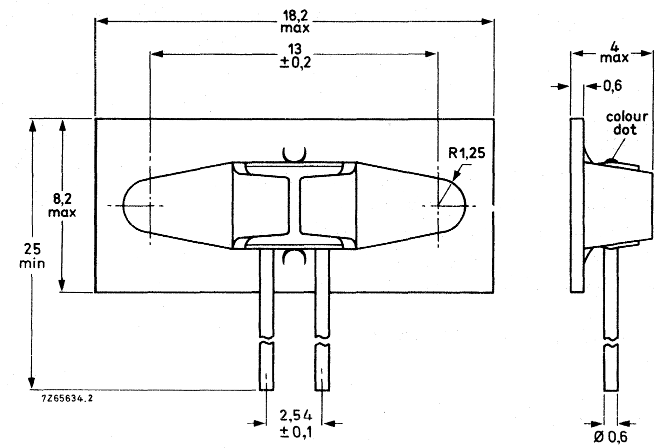


Fig.2 Type 2322 640 98005 with metal strip for mounting.

Marking

The thermistors have a blue dot.

Mass

Type 2322 640 90005	0.3 g approx.
Type 2322 640 98005	0.5 g approx.

Mounting

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

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

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

Impact

Free fall	1 m

Inflammability

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

PACKAGING

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

ELECTRICAL DATA

Unless otherwise specified, measured in accordance with IEC publication 539.

Unless otherwise stated, all values are approximate.

	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 (for information only)	310	310	kΩ
$B_{25/85}$-value	4300	4300	K
Temperature coefficient	–4.85	–4.85	%/K
Maximum dissipation	0.25	0.25	W
Dissipation factor	7	9.5	mW/K
when mounted on a heatsink (see note 1)	17.5	20.5	mW/K
Thermal time constant	19	33	s
when mounted on a heatsink (see note 1)	12	8.5	s
Heat capacity of ceramic (in air)	0.028	0.028	J/K
of complete component			
Response time (see note 2)	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 (RMS)			
between terminals and coating	min. 350	min. 350	V
Insulation resistance between terminals			
and coating at 100 V (DC)	min. 100	min. 100	MΩ

Notes

1. Measurements made in still air with the thermistor mounted on a heatsink of 100 cm^2, thickness 1.5 mm, connected between phosphor-bronze wires (ϕ 1.3 mm).
2. The thermistor being transferred from ambient air of + 25 °C to a silicone oil (MS200/50) bath of + 85 °C.

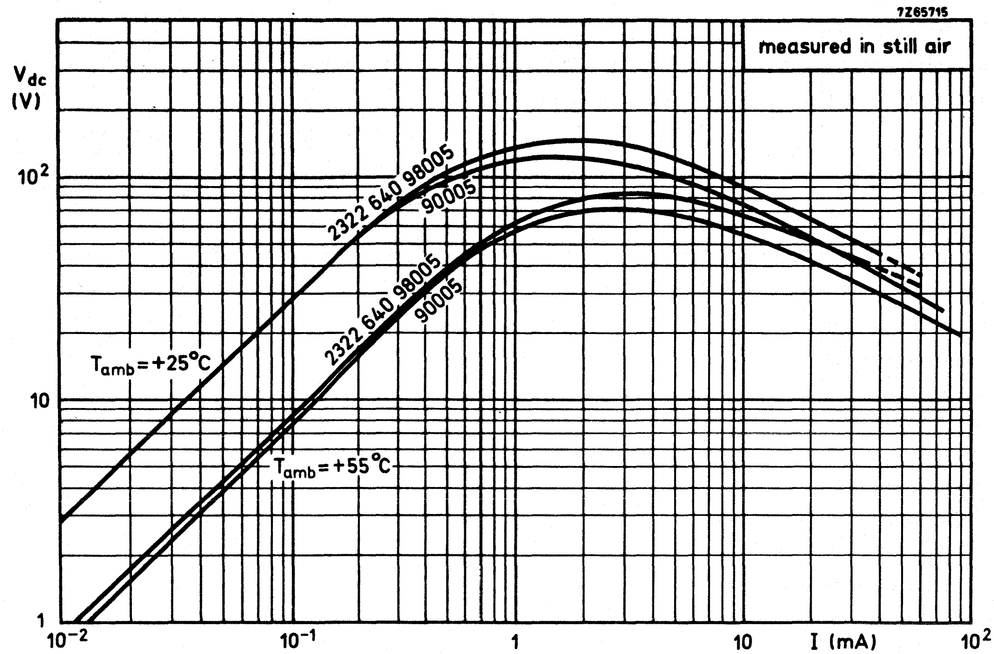


Fig.3 Typical voltage/current characteristics.

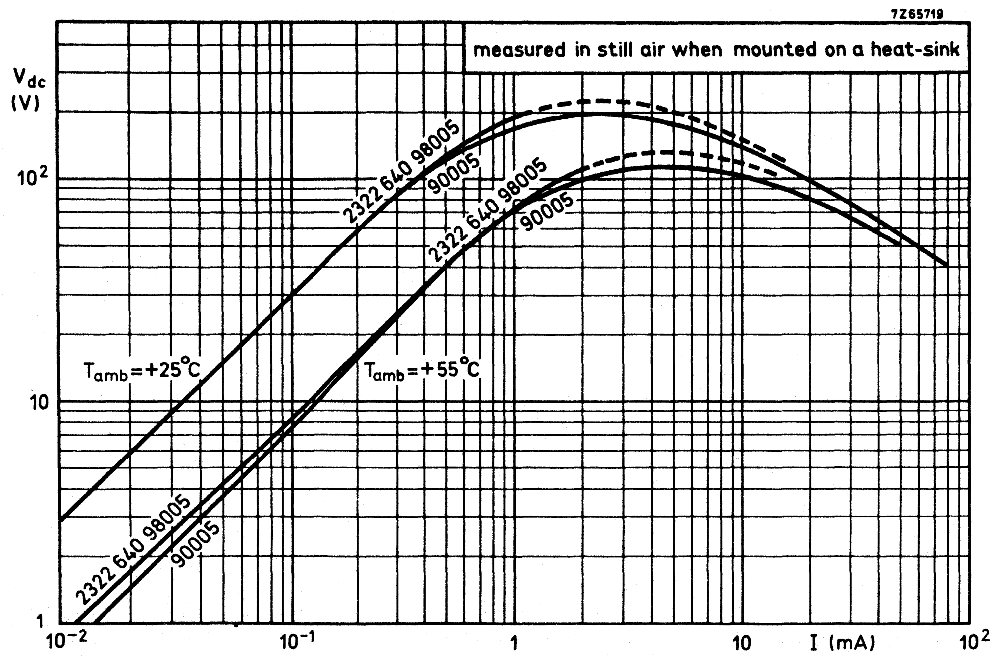


Fig.4 Typical voltage/current characteristics.

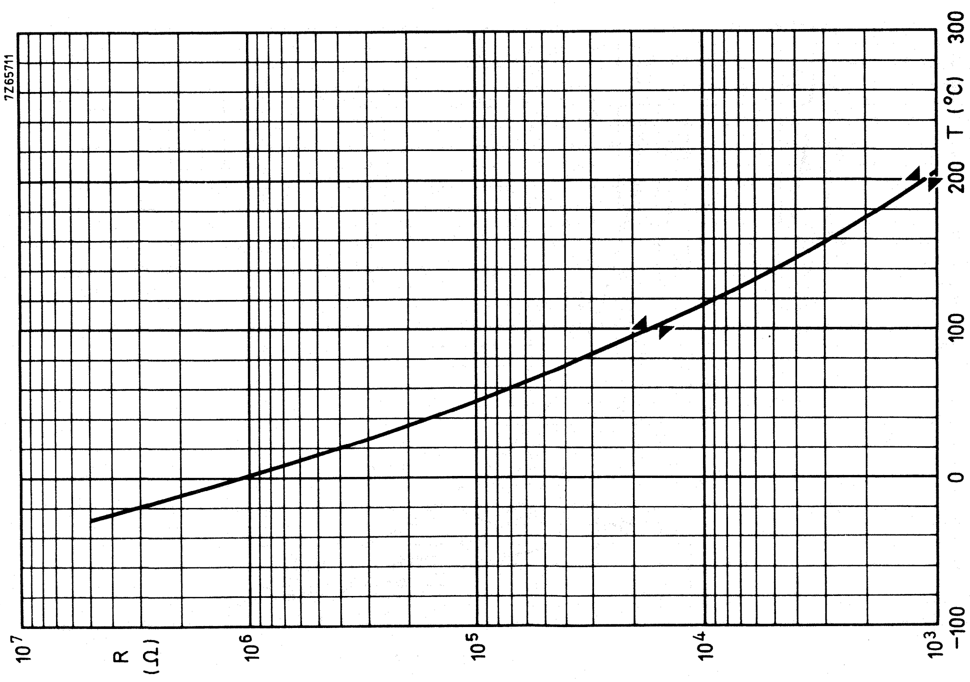


Fig.5 Typical resistance/temperature characteristics.

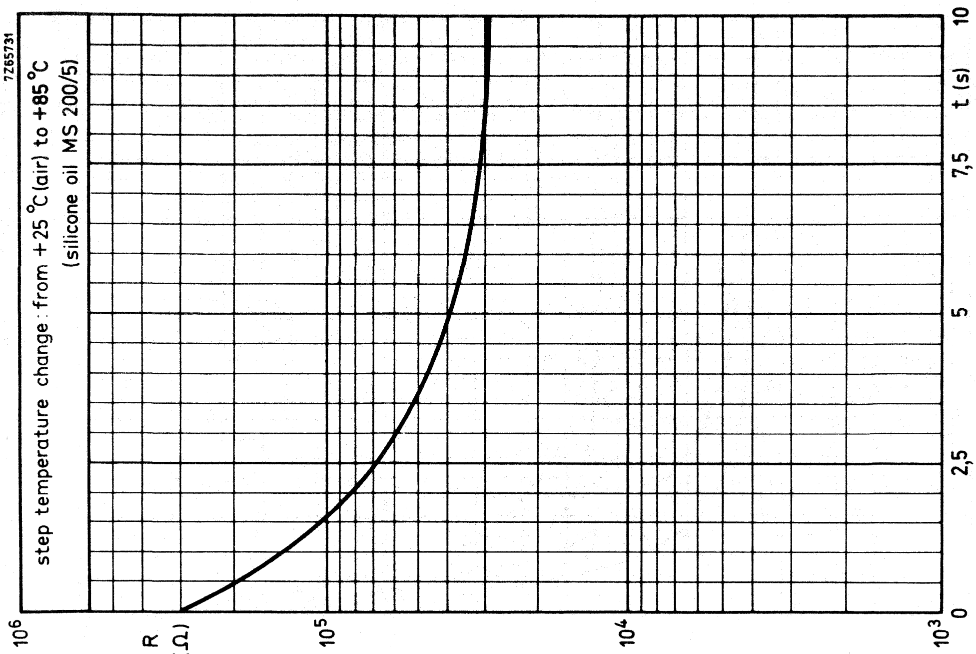


Fig.6 Typical resistance/response time characteristics.

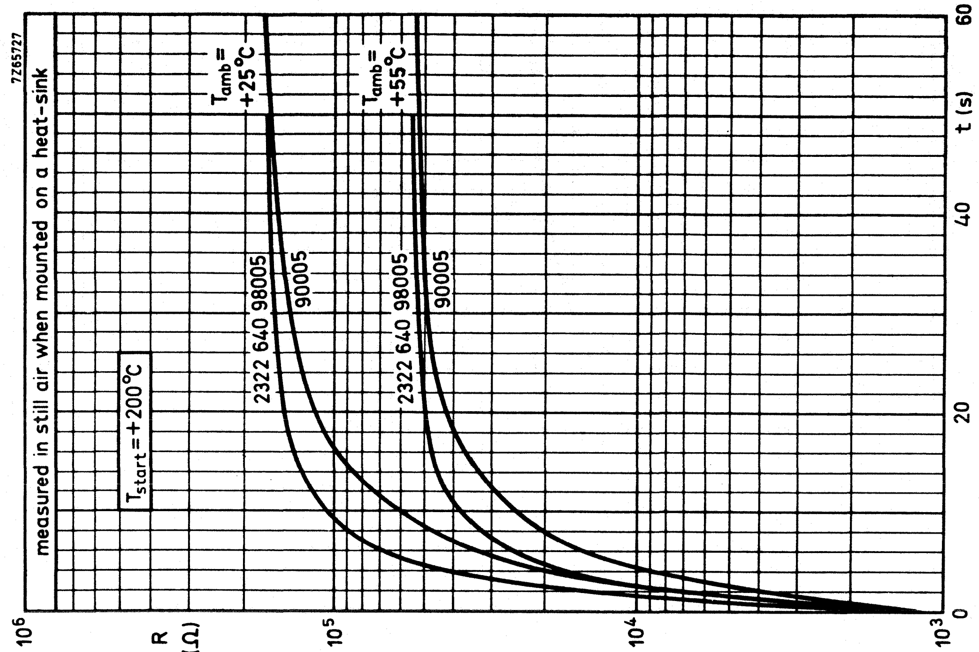


Fig.8 Typical resistance/time (cooling) characteristics.

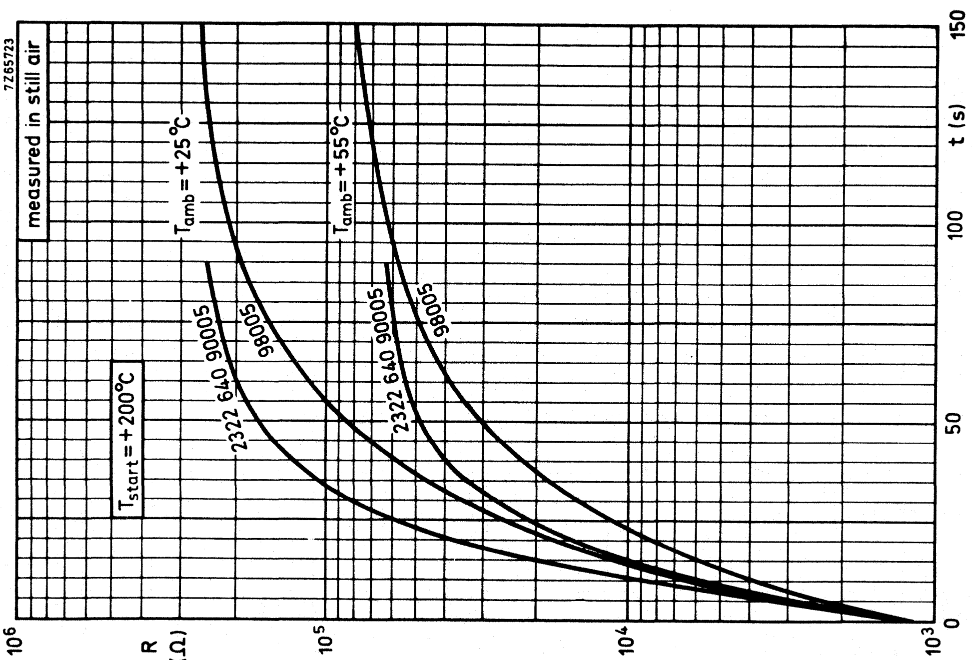


Fig.7 Typical resistance/time (cooling) characteristics.

NTC THERMISTOR
low temperature

Features

- Accurate type with several mechanical alternatives
- High stability

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at	
−30 °C	48.5 kΩ
−20 °C	26.74 kΩ
−10 °C	15.31 kΩ
Tolerance on	
R_{30} value	± 5.91% (± 1 °C)
R_{20} value	± 5.44% (± 1 °C)
R_{10} value	± 5% (± 1 °C)
Response time (for information only)	0.85 s
Operating temperature range	
at zero power	−55 to + 125 °C
for short periods	max. 150 °C
at maximum power	−55 to + 55 °C

MECHANICAL DATA

Dimensions in mm

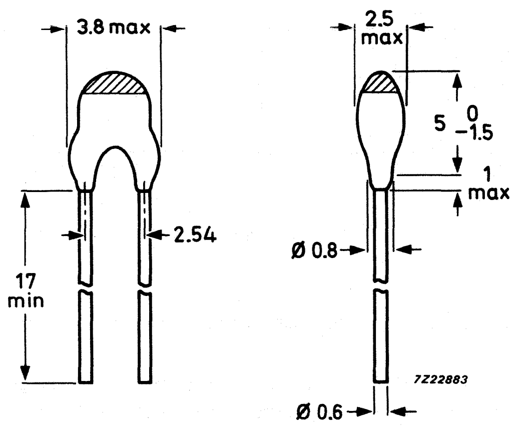


Fig.1 Component outline.

Marking: brown band on grey lacquered body

Mass: 0.21 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box containing 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	55/125/56
Resistance at (see note 1)	
− 30 °C	48.5 kΩ
− 20 °C	26.74 kΩ
− 10 °C	15.31 kΩ
Tolerance on (see note 1)	
R_{30} value	± 5.91% (± 1 °C)
R_{20} value	± 5.44% (± 1 °C)
R_{10} value	± 5% (± 1 °C)
$B_{25/85}$ value	3977 K
Response time (see note 2) (for information only)	0.85 s
Thermal time constant, τ (for information only)	8 s
Rated dissipation	250 mW
Dissipation factor, δ	7 mW/K
Operating temperature range	
at zero power	−55 to + 125 °C
for short periods	max. 150 °C
at maximum power	−55 to + 55 °C

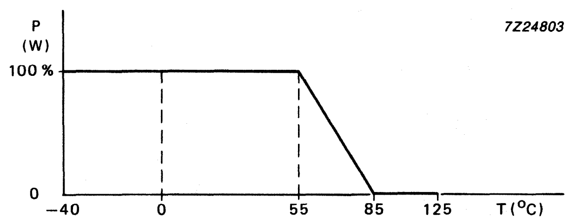


Fig.2 Tolerance curve.

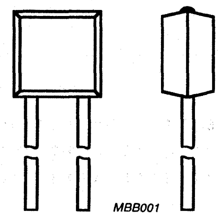
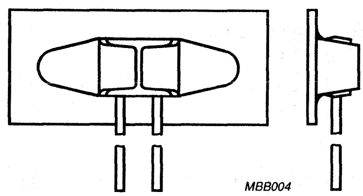
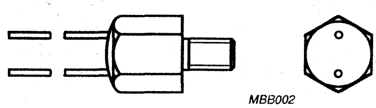
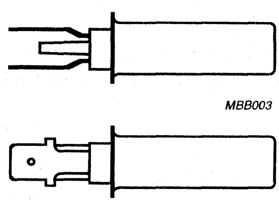
Notes

1. For values of nominal resistance value and tolerance at intermediate temperatures, please refer to Table 1.
2. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

Table 1 Resistance values at intermediate temperatures

Temperature °C	Nominal resistance value Ω	Tolerance ± %	Temperature coefficient – %/K
–40	91590	6.42	6.57
–35	66290	6.16	6.35
–30	48500	5.91	6.15
–25	35840	5.67	5.95
–20	26740	5.44	5.76
–15	20150	5.22	5.58
–10	15310	5.00	5.40
–5	11730	5.21	5.24
0	9067	5.41	5.08
5	7059	5.61	4.92
10	5539	5.80	4.78
15	4376	5.99	4.64
20	3483	6.17	4.50
25	2789	6.35	4.37
30	2248	6.52	4.25
35	1823	6.69	4.13
40	1487	6.85	4.02
45	1220	7.01	3.91
50	1006	7.17	3.80
55	833.6	7.32	3.70
60	694.5	7.46	3.60
65	851.5	7.61	3.51
70	488.9	7.75	3.42
75	413.1	7.88	3.33
80	350.3	8.02	3.25
85	298.4	8.15	3.16
90	255.3	8.27	3.09
95	219.2	8.40	3.01
100	189.0	8.52	2.94
105	163.4	8.64	2.87
110	141.8	8.75	2.80
115	123.5	8.86	2.73
120	107.9	8.98	2.67
125	94.6	9.08	2.61

ASSEMBLY VARIATIONS

catalogue number	description	outline
2322 640 90013	moulded 2322 640 90012	
2322 640 98013	moulded 2322 640 90012 with metal plate	
2322 640 97013	2322 640 90012 in screw	
2322 640 95013	2322 640 90012 in steelcap	

NTC THERMISTORS

steelcap range

Features

- Excellent in humid environments
- High mechanical strength
- AMP connectors for easy connection

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

	2322 640 90024/25	2322 640 90034
Resistance value		
at 25 °C	12 kΩ ± 5.5%	12 kΩ ± 7%
at 85 °C		1.475 kΩ ± 5%
at 100 °C	950 Ω ± 3.5%	
$B_{25/85}$ value	3740 K	
Dissipation factor		
in still air	7.5 mW/K	
in still water	18 mW/K	
Thermal time constant in still air	285 s	
Operating temperature range		
at zero power (continuously)	–25 to + 110 °C	
(for 24 hours maximum)	up to 130 °C	
at maximum power	0 to + 55 °C	

APPLICATION

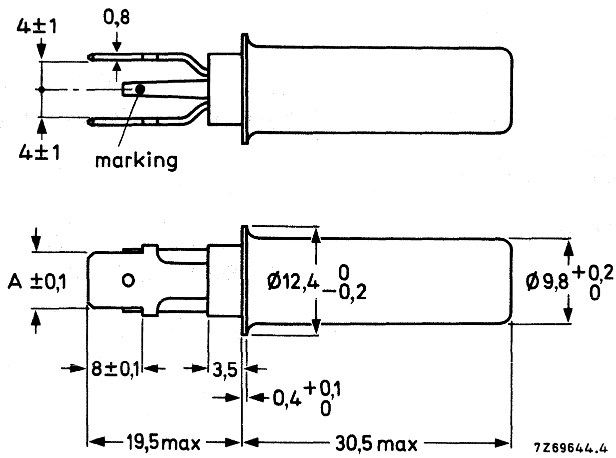
As a temperature sensor for water temperature control in washing machines, dish washers, electric boilers etc.

DESCRIPTION

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

MECHANICAL DATA

Outlines



A = 6.3 mm for thermistor types 2322 640 90034/25
A = 2.8 mm for thermistor type 2322 640 90024

Fig.1 Component outline.

Marking:	
2322 640 90024/25	blue dot between connectors
2322 640 90034	green dot between connectors
Mass:	8 grams approx.
Mounting:	in any position
Robustness of terminations:	
Tensile strength	50 N
Impact:	
Free fall	1 m
Inflammability:	the devices are non-flammable

ELECTRICAL DATA

Unless otherwise stated, all measurements are in accordance with IEC Publication 539.

	2322 640 90024/25	2322 640 90034
Resistance value		
at 25 °C	12 kΩ ± 5.5%	12 kΩ ± 7%
at 85 °C		1.475 kΩ ± 5%
at 100 °C	950 Ω ± 3.5%	
$B_{25/85}$ value	3740 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 (see note 1)	11 s	
Temperature gradient (see note 2)	0.02 K/K	
Operating temperature range		
at zero power (continuously)	−25 to + 110 °C	
(for 24 hours maximum)	up to 130 °C	
at maximum power	0 to + 55 °C	
Dielectric withstanding voltage (RMS)		
between terminals and capsule for 10 s	min. 1650 V	
between terminals and capsule for 60 s	min. 1500 V	
Insulation resistance between terminals and capsule at 100 V (DC)	min. 100 MΩ	

PACKING

The thermistors are packed in cardboard boxes, each box containing 50 items.

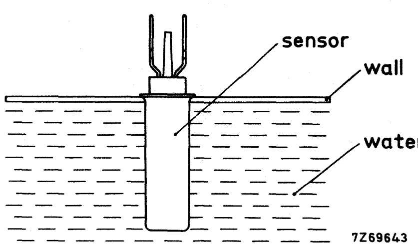


Fig.2 Method of application.

Notes

1. The thermistor being transferred from ambient air of +25 °C to water of + 100 °C.
2. 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.

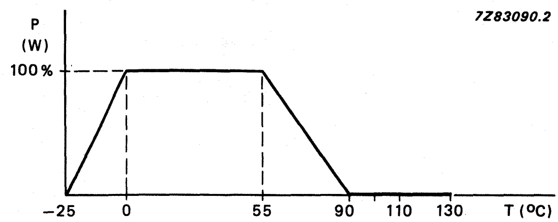


Fig.3 Power derating with ambient temperature.

NTC THERMISTOR

low temperature

Features

- High accuary at 0 °C
- High stability

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at:	
0 °C	9.000 kΩ
25 °C	2.756 kΩ
Tolerance on:	
R_0 value	± 2% (± 0.4 °C)
R_{25} value	± 4% (± 0.9 °C)
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−25 to + 55 °C

MECHANICAL DATA

Dimensions in mm

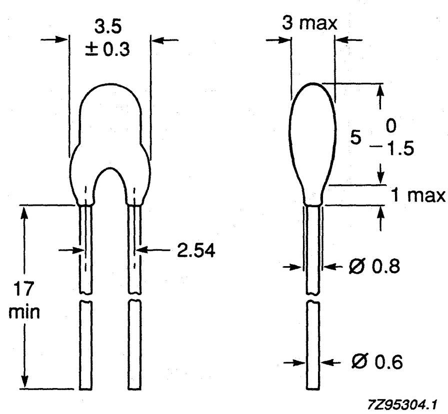


Fig.1 Component outline.

Marking: grey lacquered body, no other marking

Mass: 0.21 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box contains 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance at:	
0 °C	9.000 kΩ
25 °C	2.756 kΩ
Tolerance on:	
R_0 value	± 2% (± 0.4 °C)
R_{25} value	± 4% (± 0.9 °C)
$B_{25/85}$ value	3977 K
Response time (see note 1)	approx. 1.2 s
Rated dissipation	250 mW
Dissipation factor, δ	approx. 7 mW/K
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−25 to + 55 °C

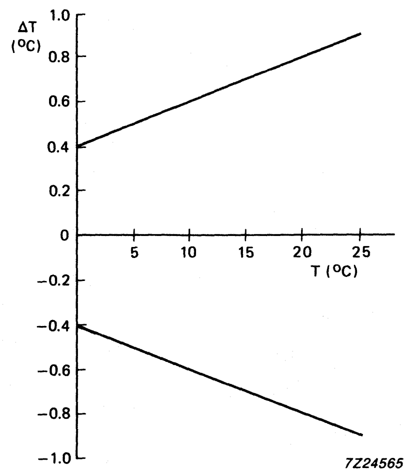


Fig.2 Tolerance curve.

Note

1. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

NTC THERMISTORS
long and insulated leads

Features

- Long and flexible leads for special mounting or assembly requirements
- Insulated leads for prevention of short circuits
- Electrical features of 'accuracy line'
- Small diameter

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at	
0 °C	66.76 kΩ
25 °C	22.19 kΩ
Tolerance on	
R_0 value	± 5%
R_{25} value	± 6.75%
$B_{25/85}$ value	3740 K
Operating temperature range	
at zero power	−40 to + 130 °C
at maximum power	0 to + 75 °C

DESCRIPTION

This thermistor has a negative temperature coefficient. It consists of a chip with two Ni insulated leads.

APPLICATION

Temperature sensing and control.

MECHANICAL DATA

Dimensions in mm

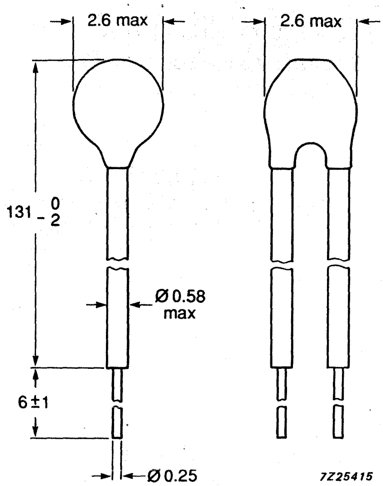


Fig.1 Component outline.

Marking

Body coated with ochre coloured epoxy lacquer

Mass

0.21 grams approximately

PACKING

The thermistors are packed in cardboard boxes, each box containing 1000 items (10 plastic bags, each containing 100 items).

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/130/56
Resistance at	
0 °C	66.76 kΩ
25 °C	22.19 kΩ
Tolerance on	
R_0 value	± 5%
R_{25} value	± 6.75%
$B_{25/85}$ value	3740 K
Rated dissipation	150 mW
Dissipation factor, δ	2.6 mW/K
Operating temperature range	
at zero power	−40 to + 130 °C
at maximum power	0 to + 75 °C

NTC THERMISTORS
low resistance range

Features

- Cost effective range with low resistance values at 25 °C

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

QUICK REFERENCE DATA

Resistance value at + 25 °C	3.3 Ω to 1.5 kΩ ←
$B_{25/85}$ value	2675 to 3975 K ←
Maximum dissipation	0.5 W
Dissipation factor	8.5 mW/K
Thermal time constant	17 s approx.
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

APPLICATION

Temperature compensation and temperature sensing.

DESCRIPTION

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

MECHANICAL DATA

Outlines

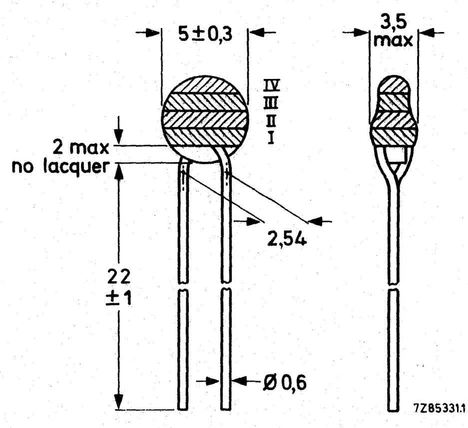


Fig.1 Component outline.

PACKAGING

500 thermistors in a cardboard box. They can be supplied on tape on request.

Marking

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

Mass

0.25 g approximately.

Mounting

In any position by soldering.

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

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

Impact

Free fall	1 m

Flammability

Not inflammable in accordance with IEC as described by TC50 (1979), needle flame.

Resistance to solvents

In accordance with IEC 68-2-45, resistant to R113 at T_{amb}.

ELECTRICAL DATA

Unless otherwise specified, measured in accordance with IEC publication 539.

Resistance at 25 °C	see Table 1
$B_{25/85}$ values	see Table 1
Temperature coefficient	see Table 1
Maximum dissipation*	0.5 W
Dissipation factor *	8.5 mW/K approx.
Thermal time constant*	17 s approx.
Operating temperature range	
at zero power	–25 to + 125 °C
at maximum power, see Fig. 2	0 to + 55 °C

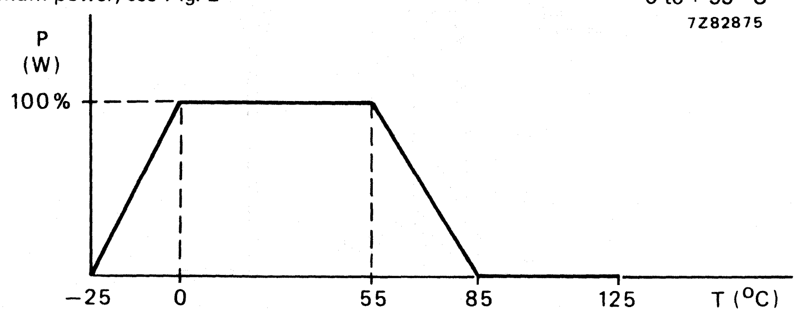


Fig. 2 Derating curve.

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

Table 1 Catalogue number 2322 642 6....

suffix of catalogue number	R_{25} Ω	$B_{25/85}$ ± 5% K	temperature coefficient %/K	colour code (see Marking) I	II	III	* IV
.338	3,3	2675	−3,0	orange	orange	gold	
.478	4,7	2750	−3,1	yellow	violet	gold	
.688	6,8	2800	−3,2	blue	grey	gold	
.109	10	2875	−3,2	brown	black	black	
.159	15	2950	−3,3	brown	green	black	
.229	22	3025	−3,4	red	red	black	
.339	33	3100	−3,5	orange	orange	black	
.479	47	3150	−3,5	yellow	violet	black	
.689	68	3225	−3,6	blue	grey	black	
.101	100	3300	−3,7	brown	black	brown	
.151	150	3375	−3,8	brown	green	brown	
.221	220	3475	−3,9	red	red	brown	
.331	330	3575	−4,0	orange	orange	brown	
.471	470	3650	−4,1	yellow	violet	brown	
.681	680	3725	−4,2	blue	grey	brown	
.102	1 000	3825	−4,3	brown	black	red	
.152	1 500	3975	−4,5	brown	green	red	

* Replace dot in catalogue number (9th digit) by:
2 for a tolerance of 10% on R_{25}, band IV is silver.
3 for a tolerance of 5% on R_{25}, band IV is gold.

NTC THERMISTOR

low power (0.5 W range)

Features

- Low power version of standard 642 6 . . . . range
- Cost effective NTC for surge current limiting in low power comsumption conditions

SURGE CURRENT LIMITING

QUICK REFERENCE DATA

Resistance value at 25 °C	3.3 Ω to 100 Ω
$B_{25/85}$ value	2675 to 3300 K
Dissipation factor	8.5 mW/K approx.

FOR DETAILED ELECTRICAL AND MECHANICAL CHARACTERISTICS, PLEASE REFER TO 2322 642 6 . . . . (low resistance range)

Table 1 Catalogue number 2322 642 6 . . . .

catalogue number 2322 642 . . . . . (see Note 1)	resistance at 25 °C Ω	max. continuous power at 55 °C W	$B_{25/85}$ value K	tolerance on $B_{25/85}$ value %	approx. dissipation factor mW/K
6*338	3.3	0.5	2675	5	8.5
6*478	4.7	0.5	2750	5	8.5
6*688	6.8	0.5	2800	5	8.5
6*109	10	0.5	2875	5	8.5
6*159	15	0.5	2950	5	8.5
6*229	22	0.5	3025	5	8.5
6*339	33	0.5	3100	5	8.5
6*479	47	0.5	3150	5	8.5
6*689	68	0.5	3225	5	8.5
6*101	100	0.5	3300	5	8.5

Note

1. Replace asterisk in catalogue number by:

   2 for a tolerance of 10% on R_{25} value (band IV is silver)

   3 for a tolerance of 5% on R_{25} value (band IV is gold)

NTC THERMISTORS

screw range

Features

- Easy mounting
- Rugged construction

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at + 25 °C	3.3 Ω to 1.5 kΩ
Dissipation factor	25 mW/K
Thermal time constant	20 s
Operating temperature range	
at zero power	−25 to + 100 °C
at maximum power	0 to + 55 °C

APPLICATION

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

DESCRIPTION

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

MECHANICAL DATA

Outline drawing

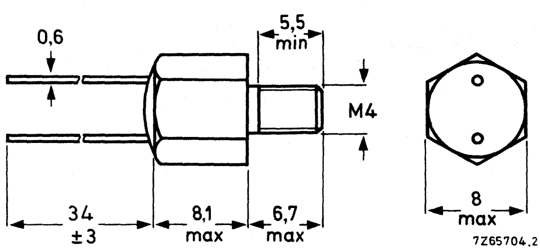


Fig.1 Component outline.

Marking

The last 4 digits of the catalogue number are printed on the stud in accordance with the information in Table 1.

Mass

1.5 g approx.

Mounting

By means of a washer and M4 nut supplied with the device.
Applied torque shall not exceed 1.2 Nm. Leads to be soldered.

Robustness of terminations

Tensile strength	10 N
Bending	5 N
Torque applied on screw	1.2 Nm max.

Soldering

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

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Maximum dissipation	0.5 W
Dissipation factor (see note 1)	25 mW/K
Thermal time constant (see note 1)	20 s approx.
Heat capacity	0.5 J/K approx.
Operating temperature range	
at zero power	−25 to + 100 °C
at maximum power	0 to + 55 °C
Dielectric withstanding voltage between terminals and screw	min. 100 V RMS
Insulation resistance between terminals and screw at 100 V DC	min. 100 MΩ

Also see Table 1.

For typical resistance/temperature and voltage/current characteristics, refer to data for type 2322 642 6 .....

Note

1. Measured with screw mounted on an aluminium heatsink of 100 cm^2, thickness 1.5 mm, in still air, T_{amb} = + 25 °C.

Table 1 Catalogue number 2322 642 7 ....

suffix of catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C
tol. 5%	tol. 10%	Ω	K	%/K
3338	2338	3.3	2675	−3.0
3478	2478	4.7	2750	−3.1
3688	2688	6.8	2800	−3.2
3109	2109	10	2875	−3.2
3159	2159	15	2950	−3.3
3229	2229	22	3025	−3.4
3339	2339	33	3100	−3.5
3479	2479	47	3150	−3.5
3689	2689	68	3225	−3.6
3101	2101	100	3300	−3.7
3151	2151	150	3375	−3.8
3221	2221	220	3475	−3.9
3331	2331	330	3575	−4.0
3471	2471	470	3650	−4.1
3681	2681	680	3725	−4.2
3102	2102	1 000	3825	−4.3
3152	2152	1 500	3975	−4.5

NTC THERMISTORS

higher power range

SURGE CURRENT LIMITING

Features

- large variety of products
- high cold resistance - negligible resistance in continuous current condition

QUICK REFERENCE DATA

Resistance value at 25 °C	2.5 Ω to 20 Ω
$B_{25/85}$ value	2950 to 3600 K
Maximum current (RMS)	2.2 to 15 A
Operating temperature range	
at zero power	–25 to 155 °C
at maximum current	0 to 55 °C

APPLICATION

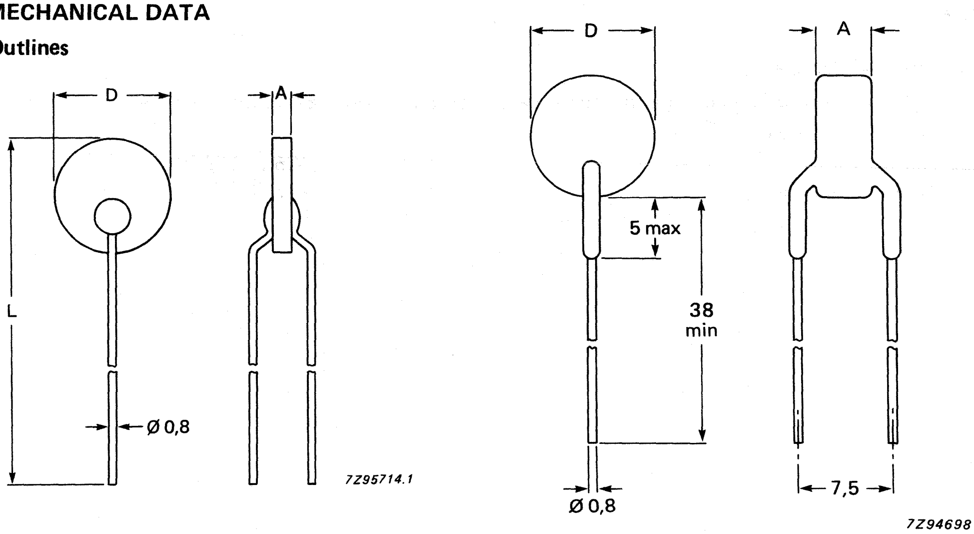
For limiting inrush current surges, preventing the blowing of fuses, provision of soft start of motors and switch protection.

DESCRIPTION

The thermistor has a negative temperature coefficient. It consists of a disc with two tinned copper wires. The thermistor body may be lacquered, depending on type (see Fig.1).

MECHANICAL DATA

Outlines



Non-lacquered types	
2322 644 90005	2322 644 90013
2322 644 90008	2322 644 90025

Lacquered types	
2322 644 90016	2322 644 90021
2322 644 90017	2322 644 90022
2322 644 90018	2322 644 90023
2322 644 90019	2322 644 90026

For dimensions A and D, refer to Table 1.

Fig.1 Outline of components.

MECHANICAL DATA (continued)

Marking: none

Mass: see Table 1

Mounting: in any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

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

Impact

Free fall	1 m

Inflammability

The thermistors are non-flammable, in accordance with IEC Publication 695-2-2 (1980, needle flame)

PACKING

The thermistors are packed in cardboard boxes; the smallest packing quantities per type are shown in Table 1.

ELECTRICAL DATA

Unless otherwise specified, all measurements are in accordance with IEC Publication 539.

Operating temperature range

at zero power	−25 to 155 °C
at maximum power	0 to 55 °C

Table 1 Electrical data

catalogue number 2322 644	R_{25} value ± 25% Ω	tolerance %	δ approx. mW/K	τ approx. s	I_{max} (RMS) A	R value at I_{max} approx. Ω	mass approx. grams	D_{max} mm	A mm	L mm	temp. coeff. %/K	$B_{25/85}$ value approx. K	smallest packing quantity
90005	⩾ 15	–	17	148	2.2	⩽ 1		16	4 ± 1	59 ± 3	–3.75	3350	100
90008	20	25			5		7.5	23.8	4 ± 1	62 ± 3	–4	3600	25
90013	20	25			6		7.5	23.8	4 ± 1	62 ± 3	–3.9	3450	25
90016	2.5	25	14	68	8	0.056	1.67	13.5	4	38 min.	–3.3	3010	100
90017	4	25	15	79	8	0.063	2.00	13.5	4.5	38 min.	–3.3	3010	100
90018	5	25	15.5	91	7	0.04	2.35	13.5	5	38 min.	–3.3	3010	100
90019	7	25	16.0	112	6	0.12	2.94	13.5	6	38 min.	–3.3	3010	100
90021	10	25	12.0	70	3	0.30	1.30	10	4.5	38 min.	–3.3	3010	100
90022	2	25	27	224	15	0.033	9.50	24	6.5		–3.3	3010	50
90023	2.5	25	28	240	12	0.048	10.40	24	7.0		–3.3	3010	50
90025	20	25			5		7.5	23.8	3.5 ± 1	60 ± 2	–4	3600	25
90026	20	25	13	75	2.2	1	1.95	10	4.5		–3.32	2950	100

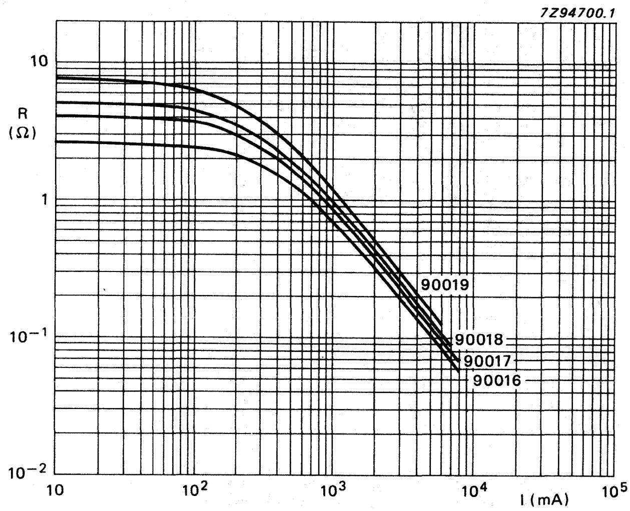


Fig.3 Typical resistance/current characteristics, types 90016 to 90019; measured in still air at 25 °C.

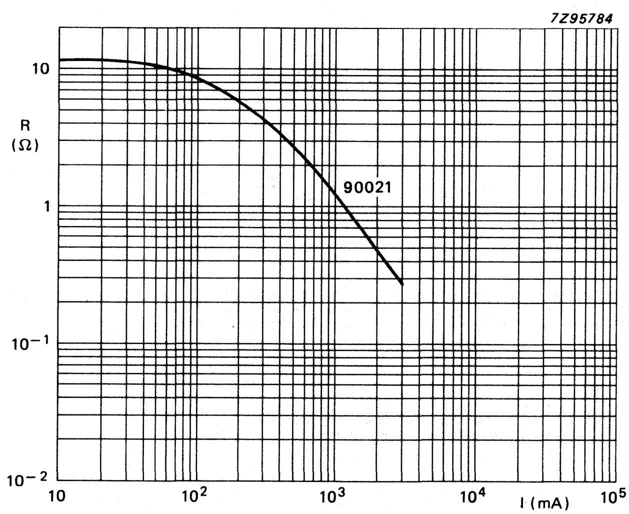


Fig.4 Typical resistance/current characteristics, type 90021; measured in still air at 25 °C.

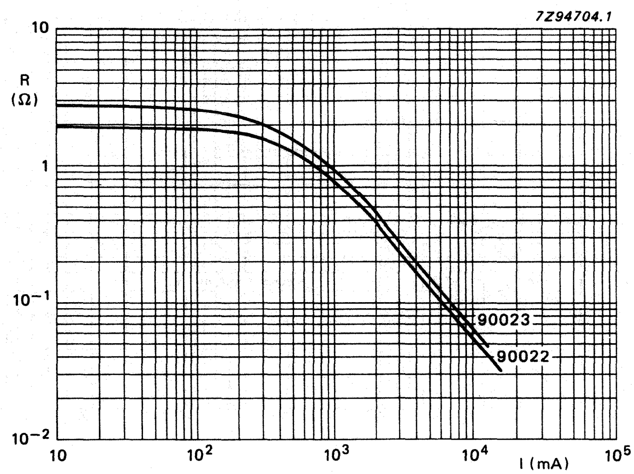


Fig.5 Typical resistance/current characteristics, types 90022, 90023; measured in still air at 25 °C.

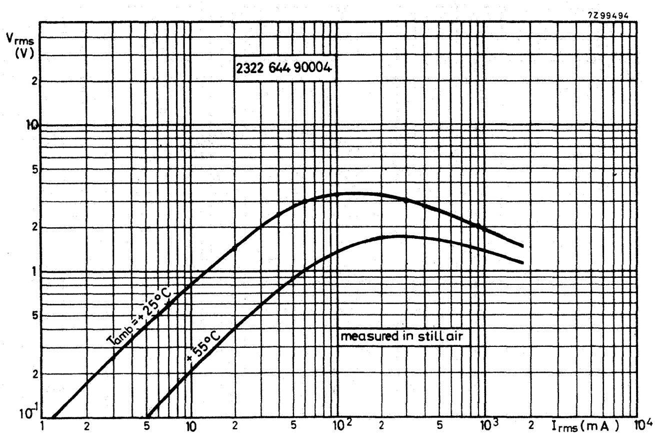


Fig.6 Typical voltage/current characteristics, type 90004; measured in still air at 25 °C.

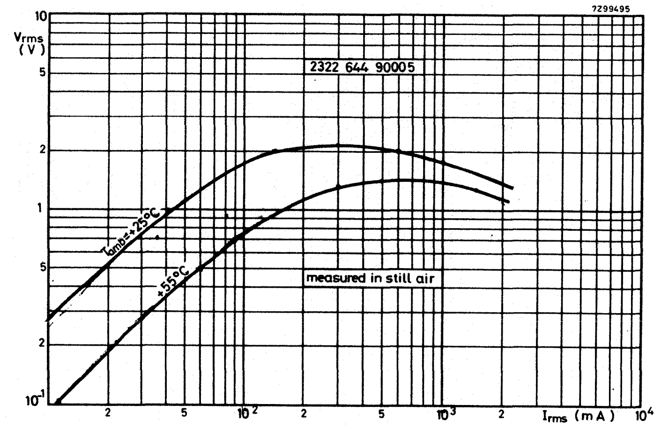


Fig.7 Typical voltage/current characteristics, type 90005; measured in still air at 25 °C.

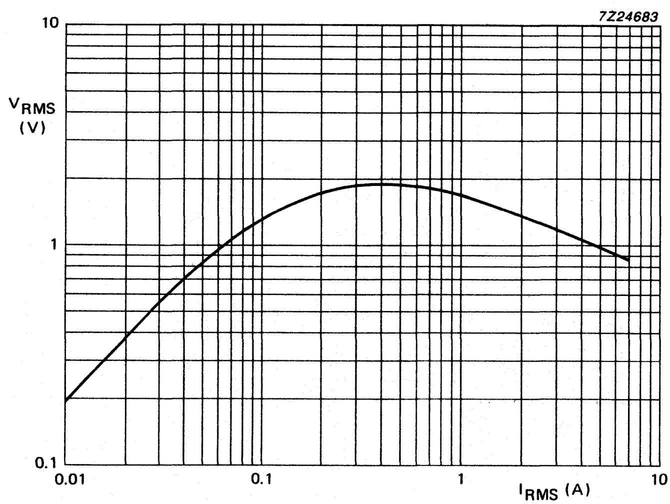


Fig.8 Typical voltage/current characteristics, type 90008; measured in still air at 25 °C.

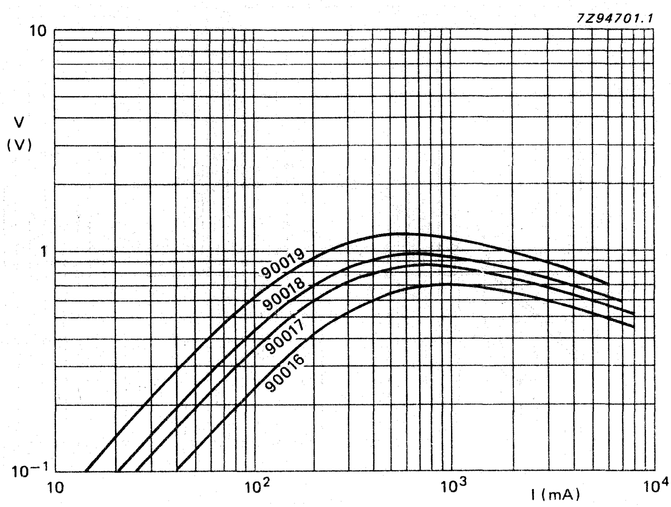


Fig.9 Typical voltage/current characteristics, types 90016 to 90019; measured in still air at 25 °C.

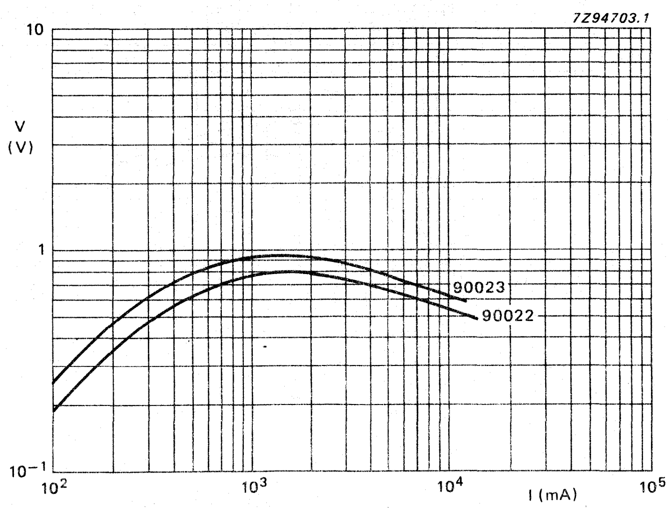


Fig.10 Typical voltage/current characteristics, types 90022, 90023; measured in still air at 25 °C.

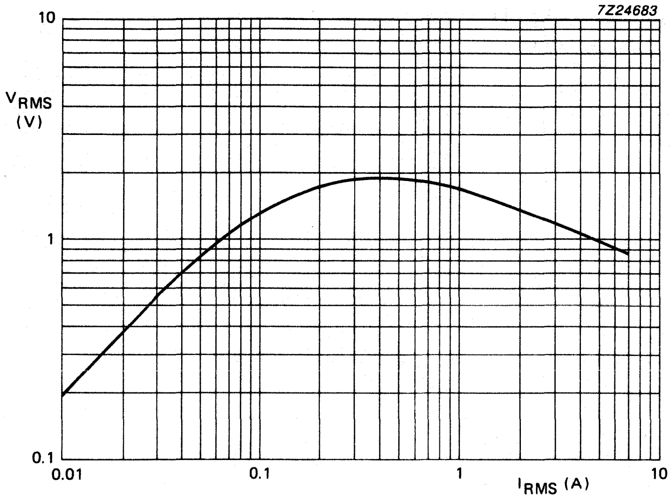


Fig.11 Typical voltage/current characteristics, type 90025; measured in still air at 25 °C.

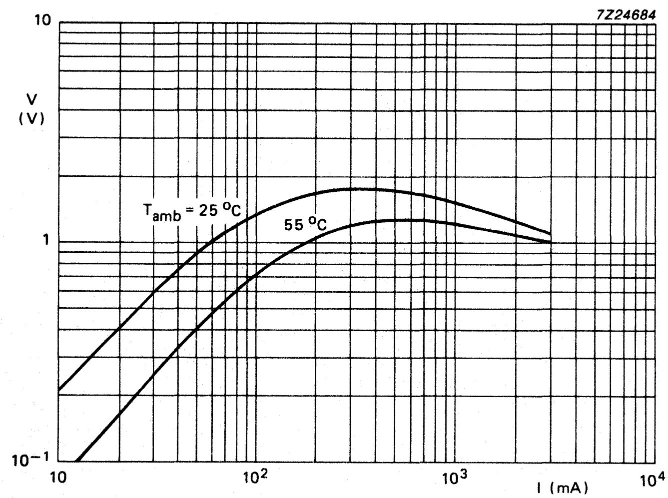


Fig.12 Typical voltage/current characteristics, type 90026; measured in still air at 25 °C.

NTC THERMISTOR

disc without leads

SURGE CURRENT LIMITING

Features

- high cold resistance - negligible resistance in continuous current condition.

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 (RMS)	8 A
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

APPLICATION

For limitation of surge current.

DESCRIPTION

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

MECHANICAL DATA

Outline drawing

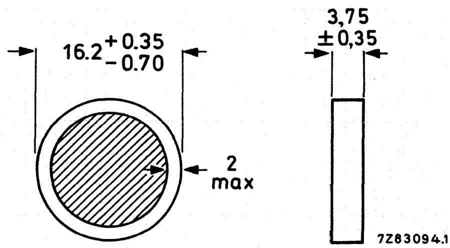


Fig. 1. Component outline.

Marking red dot in the centre of both faces, see Fig.1.

Mass 4.2 g approximately.

Mounting In any position by clamping.

Impact Free fall, 0.1 m.

Inflammability Uninflammable

PACKAGING

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

ELECTRICAL DATA

Unless otherwise specified, measured according to IEC publication 539.

Resistance value at +25 °C	5 Ω ± 20%
Resistance value at I_{RMS} = 2.2 A	max. 0.5 Ω
$B_{25/85}$-value	2975 K
Temperature coefficient	−3.35%/K
Maximum current (RMS)	8 A
Operating temperature range	
at zero power	−25 to +155 °C
at maximum power	0 to +55 °C

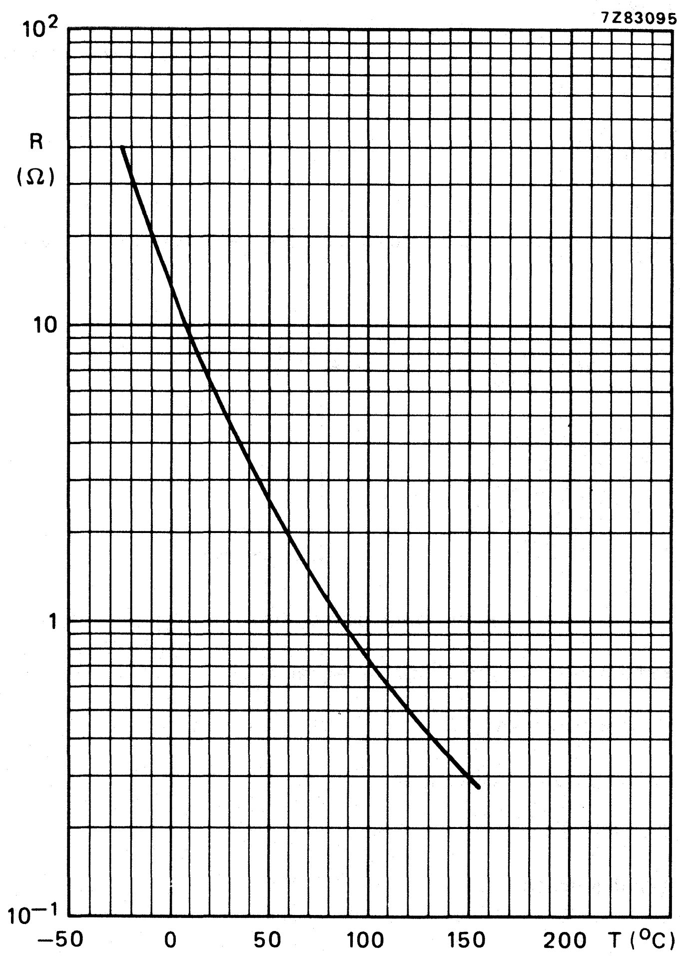


Fig. 2 Typical resistance/temperature characteristic.

NTC THERMISTORS
accuracy line
(american standard line)

Features

- Excellent accuracy over a wide temperature range (± 0.75% tolerance on B value)
- Good stability
- Good price/performance ratio

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

QUICK REFERENCE DATA

Resistance at 25 °C	1 to 10 kΩ
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.75%
Maximum dissipation	0.1 W
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to 125 °C
for short periods	max. 150 °C
at maximum power	0 to 55 °C

DESCRIPTION

These thermistors have a negative temperature coefficient. They consist of a chip or disc with two tinned solid copper wires. The range comprises 4 types which have been made from one base material, selected because of its extremely stable characteristics. The various R_{25} values are determined by the varying dimensions of the chip or disc, and the choice of R_{25} values are based on the American standard. The thermistors have a non-flammable coating of protective lacquer which, in accordance with IEC 68-2-45, is resistant to most commonly used cleaning solvents.

APPLICATION

For accurate temperature sensing, measurement and control up to 150 °C.

MECHANICAL DATA

Dimensions in mm

Outlines

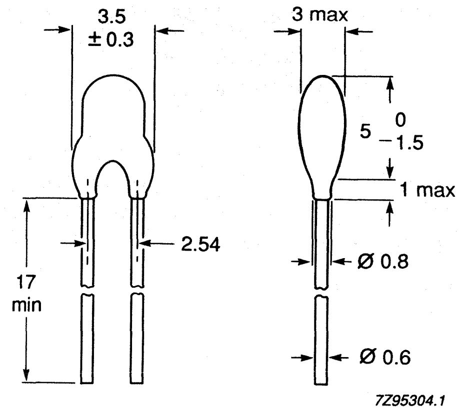


Fig.1 Component outline.

Marking : none

Mass : 0.22 grams

Mounting : by soldering, in any position

Robustness of terminations

tensile strength	10 N
bending (leads are not allowed to break or become loose)	5 N

Soldering

solderability	240 °C max., duration 4 s max.
resistance to heat	265 °C max., duration 11 s max.

Impact

free fall	1 m

Inflammability

non-flammable, in accordance with IEC publication 695-2-2 (1980, needle flame)

PACKING

The thermistors are packed in cardboard boxes. The smallest packing quantity is 500 items. The thermistors are also available on tape on special request.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with the IEC publication 539; also see Table 1.

$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.75%
Maximum dissipation	0.1 W
Dissipation factor, δ (for information only)	7 mW/K
Thermal time constant, τ (for information only)	11 s
Response time (see note 1) (for information only)	1.2 s
Operating temperature range (see Fig.2)	
at zero power	−40 to 125 °C
for short periods	max. 150 °C
at maximum power	0 to 55 °C

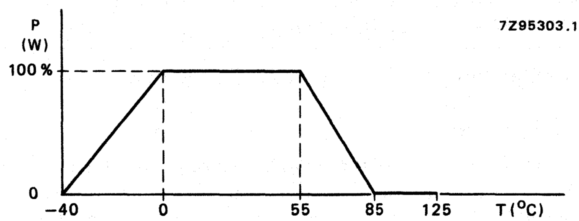


Fig.2 Derating curve.

Table 1 R_{25} values

catalogue number 2322 645 . . . . . tolerance ± 5%	catalogue number 2322 645 . . . . . tolerance ± 10%	R_{25} value kΩ
03502	02502	5
03602	02602	6
03802	02802	8
03103	02103	10

Note:

1. Response time in silicon oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air, to 85 °C in oil.

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.1%
	68-2-1	endurance	–40 °C, 1000 hours	ΔR/R < 1%	ΔR/R = 0.15%
	539-gen	endurance	100 mW, 55 °C 1000 hours	ΔR/R < 3%	ΔR/R = 0.5%
	68-2-2	dry heat, steady state	125 °C, 1000 hours	ΔR/R < 3%	ΔR/R = 0.1%
D1 4.19	68-2-3	damp heat, steady state	56 days at 40 °C, 90-95% RH	ΔR/R < 3%	ΔR/R = –0.2%
C2 4.14	68-2-14	rapid change of temperature	–40 °C to 125 °C, 50 cycles	ΔR/R < 2%	ΔR/R = 0.1%

* Typical drift based on sample products with $B_{25/75}$ value of 3965 K.

R_T values and tolerance on R_T values

These thermistors have a narrow tolerance on the B value, the result of which is to provide a very small tolerance on the nominal resistance value over a wide temperature range. For this reason the usual graphs of R = f(T) are replaced by Table 3, together with a formula with which the characteristics can be calculated with a high precision.

Formula to determine nominal resistance values.

The resistance values at intermediate temperatures can be calculated using the "Steinhert and Hart" equation:

$$R_T = \left(\frac{R_{25}}{10\,000}\right).e^{\left\{\sqrt[3]{\sqrt{E^2+D}-E} - \sqrt[3]{\sqrt{E^2+D}+E}\right\}}$$

in which $D = 4.76919 \times 10^8$ and

$$E = \frac{1.14102 - 10^3/T}{1.9786 \times 10^{-4}}$$

T = temperature in K.

Determination of the resistance/temperature deviation from nominal

The complete resistance deviation is obtained by combining the "R_{25} tolerance" and the "resistance deviation due to B tolerance".

Let X = R_{25} tolerance;

Y = resistance deviation due to B tolerance;

Z = complete resistance deviation; then:

$Z = [(1 + X/100) \times (1 + Y/100) - 1] \times 100$ or $Z = X + Y$ (approximation)

TC = temperature coefficient;

ΔT = temperature deviation, so:

$\Delta T = Z/TC$

Example: at 0 °C, let X = 5%, Y = 0.89%. and TC = 5.08 %/K (see Table 3), then

$Z = \{ [1 + (5/100)] \times [1 + (0.89/100)] - 1 \} \times 100$
$= \{ 1.05 \times 1.0089 - 1 \} \times 100 = 5.9345$ or 5.93%

$\Delta T = Z/TC = 5.93/5.08 = 1.167$ or 1.17 °C

So, a NTC having a R_{25} value of 10 kΩ has a value of 32.51 kΩ between −1.17 and + 1.17 °C.

Table 3 Resistance values at intermediate temperatures

temperature	ratio R_T/R_{25}	deviation in R value due to B tolerance	temperature coefficient	resistance value (kΩ) for 2322 645 . . . . . (see note 1)			
°C		%	%/K	0.502	0.602	0.802	0.103
−40	32.84	2.64	6.57	164.2	197.0	262.7	328.4
−35	23.77						
−30	17.39	2.16	6.15	86.95	104.3	139.1	173.9
−25	12.85						
−20	9.589	1.71	5.76	47.95	57.53	76.71	95.89
−15	7.223						
−10	5.489	1.29	5.40	27.45	32.93	43.91	54.89
−5	4.207						
0	3.251	0.89	5.08	16.26	19.51	26.01	32.51
5	2.531						
10	1.986	0.52	4.78	9.930	11.92	15.88	19.86
15	1.569						
20	1.249	0.17	4.50	6.245	7.494	9.992	12.49
25	1.000	0.0	4.37	5.000	6.000	8.000	10.00
30	0.8060	0.16	4.25	4.030	4.836	6.448	8.060
35	0.6536						
40	0.5331	0.47	4.02	2.666	3.199	4.265	5.331
45	0.4372						
50	0.3606	0.77	3.80	1.803	2.164	2.885	3.606
55	0.2989						
60	0.2490	1.05	3.60	1.245	1.494	1.992	2.490
65	0.2085						
70	0.1753	1.31	3.42	0.8765	1.052	1.402	1.753
75	0.1481						
80	0.1256	1.57	3.25	0.6280	0.7536	1.005	1.256
85	0.1070						
90	0.09155	1.81	3.09	0.4578	0.5493	0.7324	0.9155
95	0.07861						
100	0.06775	2.04	2.94	0.3388	0.4065	0.5420	0.6775
105	0.05860						
110	0.05086	2.26	2.80	0.2543	0.3052	0.4069	0.5086
115	0.04429						
120	0.03870	2.47	2.67	0.1935	0.2322	0.3096	0.3870
125	0.03392						
130	0.02982	2.67	2.55	0.1491	0.1789	0.2386	0.2982
135	0.02629						
140	0.02324	2.86	2.43	0.1162	0.1394	0.1859	0.2324
145	0.02061						
150	0.01832	3.05	2.33	0.0916	0.1099	0.1466	0.1832

Note:

1. Replace dot in catalogue number by 2 for a ± 10% tolerance, and 3 for a ± 5% tolerance.

NTC THERMISTOR
medium temperature

Features

- accurate type with several mechanical alternatives
- high stability

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at 25 °C	10 kΩ
Tolerance on R_{25} value	± 3% (0.7 °C)
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−55 to + 55 °C

MECHANICAL DATA

Dimensions in mm

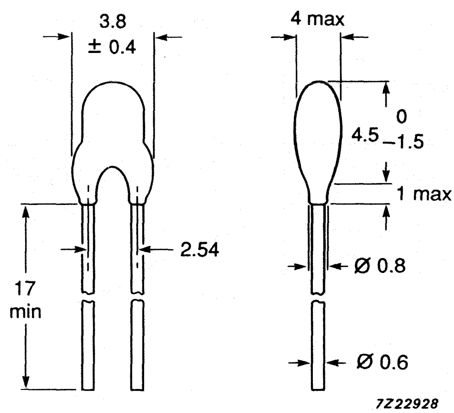


Fig.1 Component outline.

Marking: grey lacquered body

Mass: 0.18 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box containing 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance at 25 °C (see note 1)	10 kΩ
Tolerance on R_{25} value	± 3% (0.7 °C)
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
$B_{25/85}$ value	3977 K
Response time (see note 2) (for information only)	1.2 s
Rated dissipation	100 mW
Dissipation factor, δ	7 mW/K approx.
Operating temperature range	
at zero power	–40 to + 125 °C
for short periods	max. 150 °C
at maximum power	–55 to + 55 °C

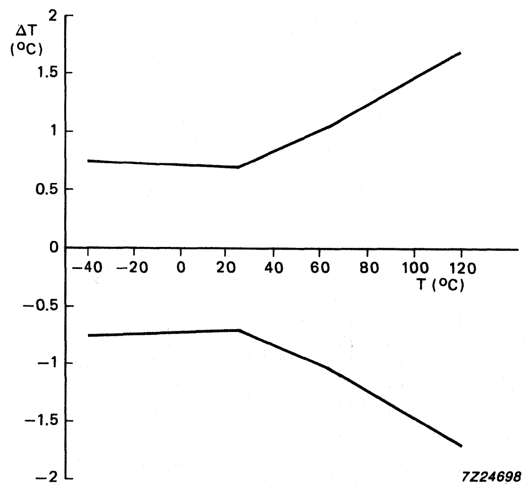


Fig.2 Tolerance curve.

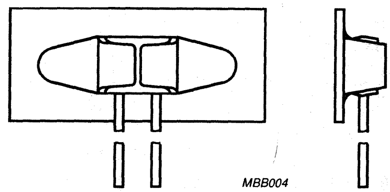
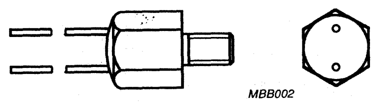
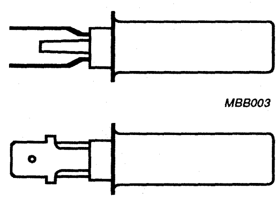
Notes

1. For values of nominal resistance value and tolerance at intermediate temperatures, please refer to Table 1.
2. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

Table 1 Resistance values at intermediate temperatures

Temperature °C	Nominal resistance value kΩ	Tolerance ± %	Temperature coefficient – %/K
–40	328.4	4.80	6.57
–35	237.7		
–30	173.9	4.50	6.15
–25	128.5		
–20	95.89	4.16	5.76
–15	72.23		
–10	54.89	3.88	5.40
–5	42.07		
0	32.51	3.60	5.08
5	25.31		
10	19.86	3.36	4.78
15	15.69		
20	12.49	3.12	4.50
25	10.00	3.00	4.37
30	8.06	3.12	4.25
35	6.536		
40	5.331	3.32	4.02
45	4.372		
50	3.606	3.52	3.80
55	2.989		
60	2.49	3.72	3.60
65	2.085		
70	1.753	3.88	3.42
75	1.481	3.96	3.33
80	1.256	4.04	3.25
85	1.070		
90	0.9155	4.20	3.09
95	0.7861		
100	0.6775	4.36	2.94
105	0.5860		
110	0.5086	4.52	2.80
115	0.4429		
120	0.3870	4.68	2.67
125	0.3392		
130	0.2982	4.84	2.61
135	0.2629		
140	0.2324	4.97	2.43
145	0.2061		
150	0.1832	5.1	2.33

ASSEMBLY VARIATIONS

catalogue number	description	outline
2322 645 98001	moulded 2322 645 90001 with metal plate	
2322 640 97001	2322 645 90001 in screw	
2322 645 95001	2322 645 90001 in steelcap	

NTC THERMISTOR
low temperature

Features

- high accuracy over a wide temperature range
- high stability

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance value at 25 ^{o}C	5 kΩ
Tolerance on R_{25} value	± 3% (± 0.7 ^{o}C)
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to + 125 ^{o}C
for short periods	max. 150 ^{o}C
at maximum power	−40 to + 55 ^{o}C

MECHANCIAL DATA

Dimensions in mm

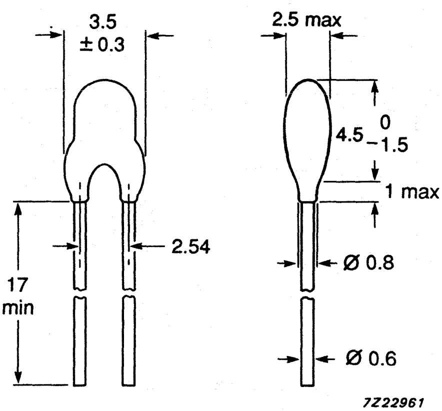


Fig.1 Component outline.

Marking: grey lacquered body, no other marking

Mass: 0.21 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box containing 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance value at 25 °C (note 1)	5 kΩ
Tolerance on R_{25} value	± 3% (± 0.7 °C)
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
$B_{25/85}$ value	3977 K
Response time (see note 2) (for information only)	1.2 s
Rated dissipation	250 mW
Dissipation factor, δ (for information only)	7 mW/K
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−40 to + 55 °C

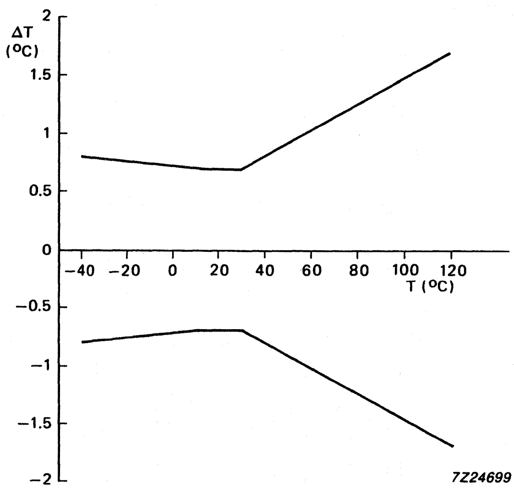


Fig.2 Tolerance curve.

Notes:

1. For values of nominal resistance value and tolerance at intermediate temperatures, please refer to Table 1.
2. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

Formula to determine nominal resistance values

The resistance values at intermediate temperatures can be calculated using the modified 'Steinhart and Hart' equation:

$$R_T = (R_{25}/10000)\ [\sqrt[3]{(\sqrt{E+D}-E)} - \sqrt[3]{(\sqrt{E+D}+E)}]$$

in which $D = 4.76919 \times 10^8$

and $E = \dfrac{1.4102 - 10^3/T}{1.9786 \times 10^{-4}}$

T is measured in Kelvin.

Table 1 Resistance values at intermediate temperatures

Temperature °C	Ratio R_T/R_{25}	Resistance kΩ	Deviation in R value due to B tolerance %	Temperature coefficient %/K
–40	32.84	164.2	4.80	–6.57
–35	23.77			
–30	17.39	86.95	4.50	–6.15
–25	12.85			
–20	9.589	47.95	4.16	–5.76
–15	7.223			
–10	5.489	27.45	3.88	–5.40
–5	4.207			
0	3.251	16.26	3.60	–5.08
5	2.531			
10	1.986	9.930	3.36	–4.78
15	1.569			
20	1.249	6.245	3.12	–4.50
25	1.000	5.000	3.00	–4.37
30	0.8060	4.030	3.12	–4.25
35	0.6536			
40	0.5331	2.666	3.32	–4.02
45	0.4372			
50	0.3606	1.803	3.52	–3.80
55	0.2989			
60	0.2490	1.245	3.72	–3.60
65	0.2085			
70	0.1753	0.8765	3.88	–3.42
75	0.1481			
80	0.1256	0.6280	4.04	–3.25
85	0.1070			
90	0.09155	0.4578	4.20	–3.09
95	0.07861			
100	0.06775	0.3388	4.36	–2.94
105	0.05860			
110	0.05086	0.2543	4.52	–2.80
115	0.04429			
120	0.03870	0.1935	4.68	–2.67
125	0.03392			

NTC THERMISTOR
medium temperature

Features

- excellent accuracy over a wide temperature range
- high stability

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at 25 °C	5 kΩ
Tolerance on R_{25} value	± 2%
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
Response time (for information only)	1.2 s
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−40 to + 55 °C

MECHANICAL DATA

Dimensions in mm

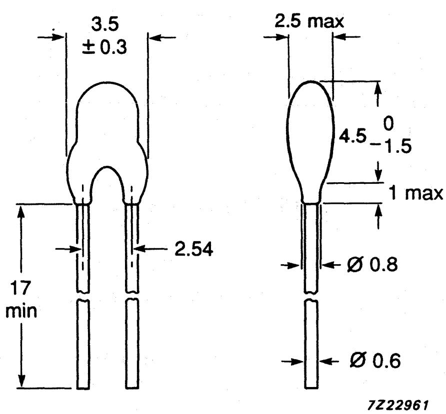


Fig.1 Component outline.

Marking: grey lacquered body

Mass: 0.21 grams approx.

PACKING

The thermistors are packed in cardboard boxes, each box containing 500 items.

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance at 25 °C (see note 1)	5 kΩ
Tolerance on R_{25} value	± 2%
$B_{25/75}$ value	3965 K
Tolerance on $B_{25/75}$ value	± 0.5%
$B_{25/85}$ value	3977 K
Response time (see note 2) (for information only)	1.2 s
Rated dissipation	100 mW
Dissipation factor, δ	7 mW/K approx.
Operating temperature range	
at zero power	−40 to + 125 °C
for short periods	max. 150 °C
at maximum power	−40 to + 55 °C

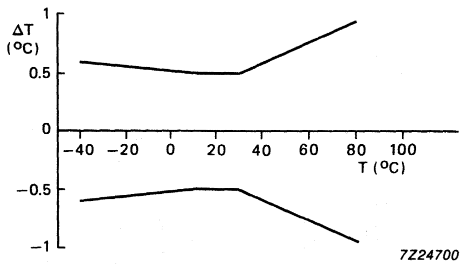


Fig.2 Tolerance curve.

Notes:

1. For values of nominal resistance value and tolerance at intermediate temperatures, please refer to Table 1.
2. Response time in silicone oil MS 200/50. This is the time needed for the sensor to reach 63.2% of the total temperature difference when subjected to a temperature change, in this case from 25 °C in air to 85 °C in oil.

Table 1 Resistance values at intermediate temperatures

Temperature °C	Nominal resistance value kΩ	Tolerance ± %	Temperature coefficient – %/K
−40	164.2	3.80	6.57
−35			
−30	86.95	3.50	6.15
−25			
−20	47.95	3.16	5.76
−15			
−10	27.45	2.88	5.40
−5			
0	16.26	2.60	5.08
5			
10	9.93	2.36	4.78
15			
20	6.245	2.25	4.50
25	5.000	2.18	4.37
30	4.03	2.12	4.25
35			
40	2.666	2.32	4.02
45			
50	1.803	2.52	3.80
55			
60	1.245	2.72	3.60
65			
70	0.8765	2.88	3.42
75			
80	0.6280	3.04	3.25
85			
90	0.4578	3.20	3.09
95			
100	0.3388	3.36	2.94
105			
110	0.2543	3.52	2.80
115			
120	0.1935	3.68	2.67
125			
130	0.1491	3.81	2.55
135			
140	0.1162	3.94	2.43
145			
150	0.0916	4.07	2.33

NTC THERMISTOR
long leads

Features

- Long and flexible leads for special mounting or assembly requirements
- Electrical features of 'accuracy line'
- Small diameter

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

Resistance at 25 °C	10 kΩ
Tolerance on R_{25} value	± 5%
$B_{25/100}$ value	3993 K ± 1.2%
Operating temperature range	
at zero power	−40 to + 125 °C
at maximum power	0 to + 55 °C

DESCRIPTION

This thermistor has a negative temperature coefficient. It consists of a chip with two Ni leads.

APPLICATION

Temperature sensing and control.

MECHANICAL DATA

Dimensions in mm

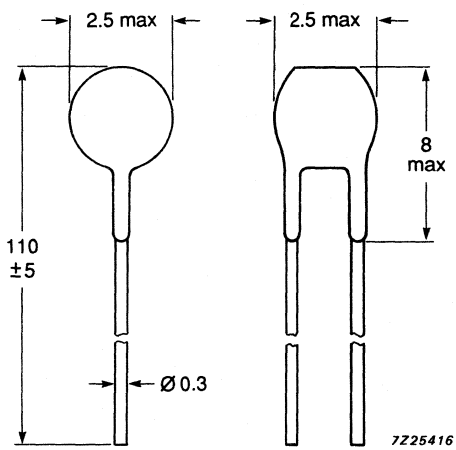


Fig.1 Component outline.

MECHANICAL DATA (continued)

Marking

Body coated with black coloured EPQ lacquer

Mass

0.21 grams approximately

PACKING

The thermistors are packed in cardboard boxes, each box containing 1000 items (10 plastic bags, each containing 100 items).

ELECTRICAL DATA

Unless otherwise stated, measurements are in accordance with IEC Publication 539.

Climatic category	40/125/56
Resistance at 25 °C	10 kΩ
Tolerance on R_{25} value	± 5%
$B_{25/100}$ value	3993 K ± 1.2%
Rated dissipation	100 mW
Dissipation factor, δ	1.35 mW/K
Operating temperature range	
at zero power	−40 to + 125 °C
at maximum power	0 to + 55 °C

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS (PTC)

INTRODUCTION

1. GENERAL

Positive Temperature Coefficient (PTC) thermistors exhibit a high positive temperature coefficient of resistance. They differ from Negative Temperature Coefficient (NTC) thermistors in the following manner:

1. The temperature coefficient of a PTC is positive only between certain temperatures. Outside this range, the temperature coefficient is either zero or negative.
2. The absolute value of the temperature coefficient of PTC thermistors is much higher than that of NTC thermistors.

PTC thermistors are used in a variety of applications, including current limiting, temperature sensing, degaussing and for protection against overheating in equipment such as electric motors. They may also be used in level indicators, time delay devices, thermostats, and as compensation resistors. For further details, refer to the 'Applications' section.

2. ELECTRICAL COMPOSITION

PTC thermistors are prepared from $BaTiO_3$, by a similar method to that used in the preparation of NTC thermistors, using solid solutions of $BaTiO_3$. Extra electrons on the Ti ions are created by introducing foreign ions having a different valency. Use of these compounds allows two alternatives for preparation:

1. Substitution of trivalent ions such as La^{3+} or Bi^{3+} for Ba^{3+}, or
2. Substitution of pentavalent ions such as Sb^{5+} or Nb^{5+} for Ti.

Both methods give identical results. If prepared in the absence of oxygen, these semiconductors exhibit a weak temperature coefficient of resistance. A strong positive coefficient is obtained by firing the ceramic samples in an oxygen rich atmosphere. This is achieved by penetrating the pores and crystal boundaries with oxygen during the cooling period following the firing process. The oxygen atoms, which have been absorbed on the crystal surfaces, attract electrons from a thin zone of the semiconducting crystals. This forms electrical potential barriers 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 in the thermistor, exhibited by the formula:

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

where, 'a' represents the size of the crystallites, thus 1/a is the number of barriers per unit length of the thermistor, and V_b represents the potential of the barriers. Since V_b is inversely proportional to the value of the dielectric constant of the crystals, R_b is extremely sensitive to variations in the dielectric constant. Such variation in the dielectric constant is a special property of materials having a ferroelectric nature as can be found in the compound $BaTiO_3$ and its solid solutions. If their ferroelectric Curie temperature (θ) is exceeded, the relative dielectric constant decreases with the temperature increase in accordance with the relationship shown overleaf:

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

where C has an approximate value of 10^5 K. As a result, the resistivity increases sharply 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 polarisation of the crystals which may compensate the boundary changes.

The electrons are captured at the boundaries and gradually liberated in proportion with the increase in body temperature of the PTC with respect to its switching temperature, causing the potential barriers to decrease in strength. This means that the PTC loses its properties and may eventually respond in a similar fashion to a NTC if the temperature becomes too high. The applications of a PTC are, therefore, restricted by a certain temperature limit.

Since 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 frequency dependence of an extra impedance Z_b up to 5 MHz. The characteristic properties described in the following paragraphs are thus restricted to this frequency range.

3. ELECTRICAL PROPERTIES

Resistance/temperature characteristics

Figure 1 shows a comparison of typical resistance/temperature characteristic curves for PTC and NTC thermistors.

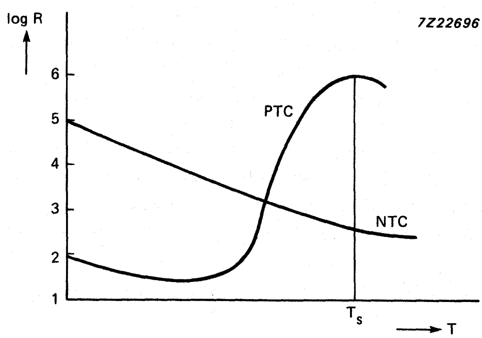


Fig.1 Typical resistance/temperature characteristic curves for PTC and NTC thermistors.

Voltage/current characteristics

Static voltage/current characteristics display the current limiting ability of PTC thermistors. Up to a certain value of voltage, the V/I characteristics follow Ohm's law, but the resistance is increased when the current passing through the PTC causes it to heat up and reach its switching temperature (see Fig.2). The V/I characteristic is dependent on ambient temperature and the heat transfer coefficient with respect to ambient temperature.

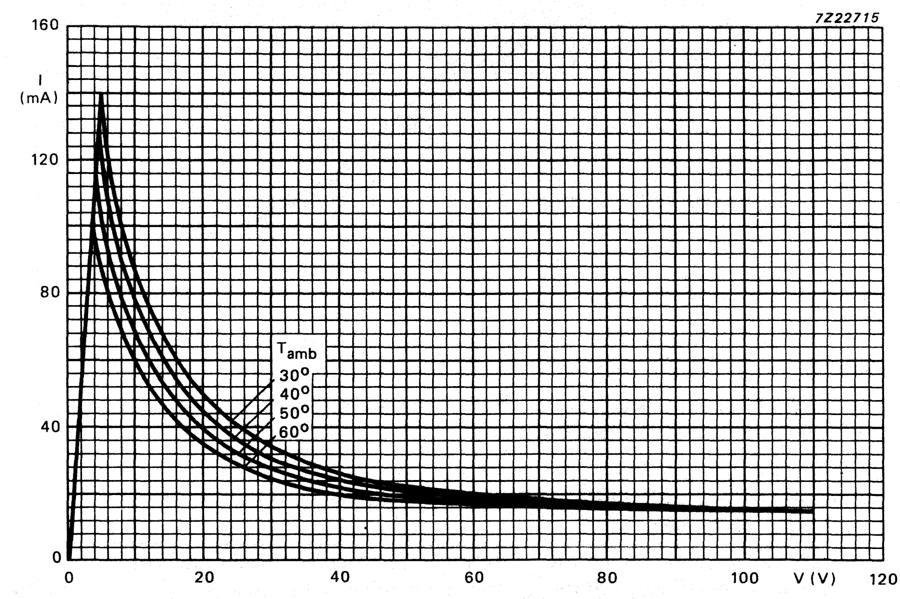


Fig.2 Voltage/current characteristics of a PTC thermistor plotted on a linear scale, using ambient temperature as the parameter.

As can be seen from Fig.2, the characteristics are plotted on a linear scale, however it is more common to plot the characteristics on a logarithmic scale (see Fig.3), since it gives a clearer view of the overall response.

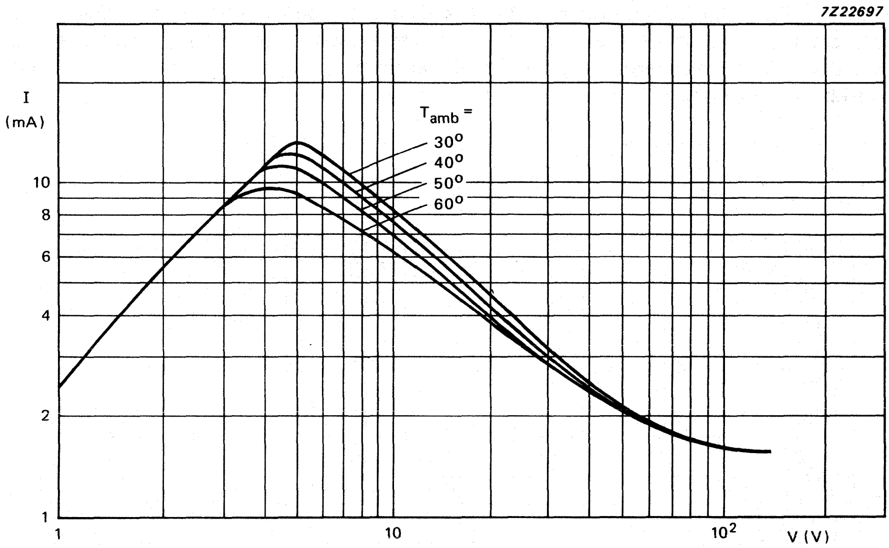


Fig.3 Voltage/current characteristics of a PTC thermistor plotted on a logarithmic scale, and using ambient temperature as the parameter.

It is possible to calculate the peak of the V/I characteristic accurately if the R/T characteristic and the dissipation factor (D) are known.

The dissipation factor (measured in mW/°C) is the ratio at a specified ambient temperature of a change in power dissipation in a thermistor, to the resultant body temperature change. By convention, the dissipation factor can only be calculated at the peak of the V/I curve, also making use of the corresponding point on the R/T characteristic.

By definition:

– the electrical power injected in the PTC thermistor is:

$$P = I^2 R$$

where R is the resistance (before switching) at T_{amb}

– the power dissipated by the ceramic is given by:

$$D\ (T_s - T_{amb})$$

where T_s is the switch temperature and T_{amb} is the ambient temperature, then,

$$I^2 R = D\ (T_s - T_{amb})$$

Note: This equation is only valid for temperatures having a value less than T_s.

The trip current (I_t) is defined as the minimum guaranteed current which will cause the thermistor to switch, and can be calculated using the formula:

$$I_t^2 R = D \; [T_s - (T_{amb} + \omega)] \text{, hence:}$$

$$I_t = \sqrt{\frac{D[T_s - (T_{amb} + \omega)]}{R}}$$

where R is the PTC resistance at T_{amb}.

Normally, a security margin of $+\omega$ °C is maintained in order to assure thermistor switching due to inaccuracies in the values of T_s and T_{amb}.

The non-trip current (I_{nt}) is defined as the guaranteed maximum current at which the thermistor will not switch, and is given by:

$$I_{nt}^2 R = D[T_s - (T_{amb} - \omega)] \text{, hence:}$$

$$I_{nt} = \sqrt{\frac{D[T_s - (T_{amb} - \omega)]}{R}}$$

A security margin of $-\omega$ °C is maintained to ensure that the thermistor will not switch.

The slope of the R/T characteristic is designated by a series of production parameters. The relationship between R/T and V/I characteristics is demonstrated clearly in Figs 4 and 5.

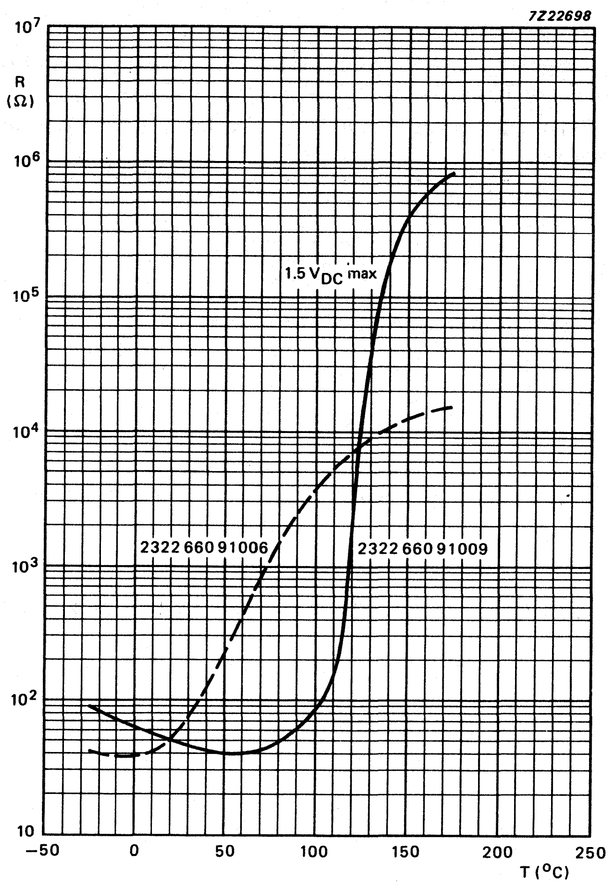


Fig.4 R/T characteristics of thermistors type 2322 660 91006 and 2322 660 91009.

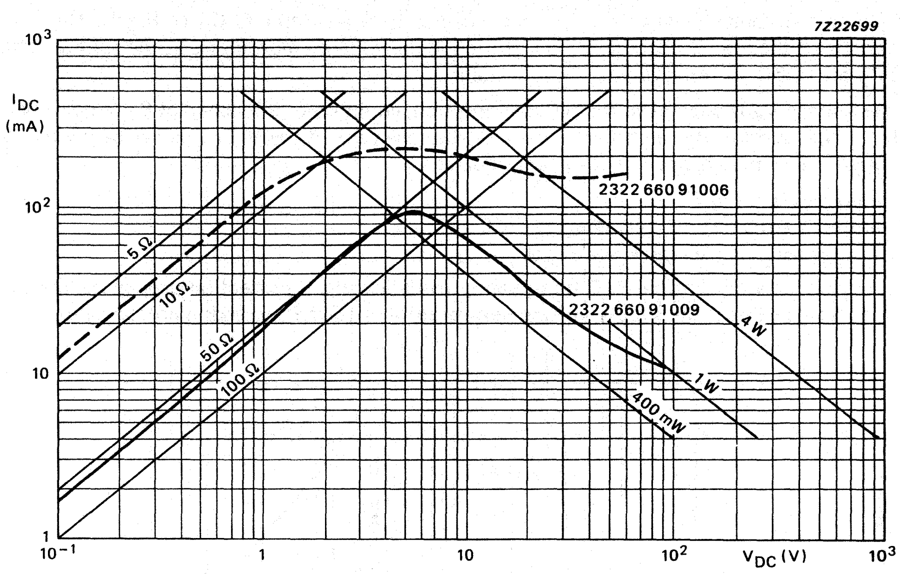


Fig.5 Typical V/I characteristics of thermistors type 2322 660 91006 and 2322 660 91009, measured in still air at 25 °C.

PTC thermistor in series with a load

It can be shown from the V/I characteristics that, because of the non-linearity of the PTC curve, three working points are possible when a load R is connected in series with a PTC (see Fig.6). The characteristic of the load is a straight line intersecting the voltage co-ordinates at the supply voltage, V_a. 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 is reached at P_1, a point with a relatively high current. P_2 can only be reached when the peak of the V/I curve lies below the load characteristic. This may happen in a number of cases:

1. V_a increases, see Fig.7.
2. the ambient temperature increases, see Fig.8
3. the load resistance decreases, see Fig.9.

It can therefore be seen that the PTC thermistor provides excellent protection properties, limiting the load to a safe value if the supply voltage, temperature or current exceeds a critical value.

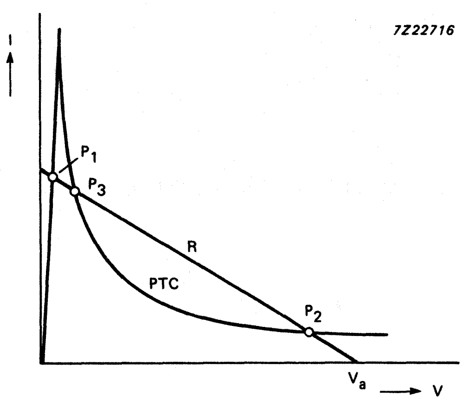


Fig.6 PTC thermistor in series with a load showing the possible working points.

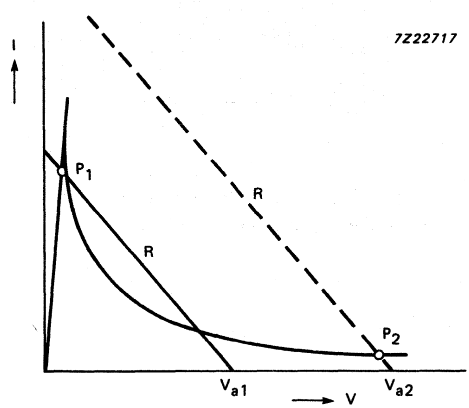


Fig.7 PTC thermistor in series with a load showing the influence of the supply voltage V_a.

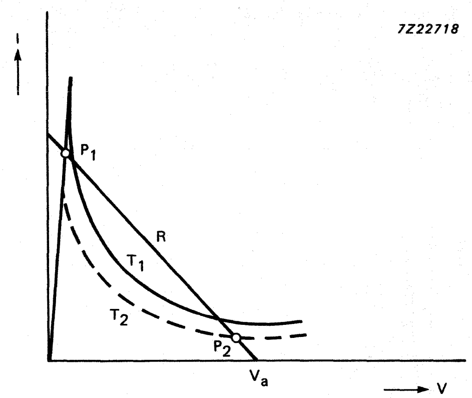


Fig.8 PTC thermistor in series with a load showing the influence of the ambient temperature.

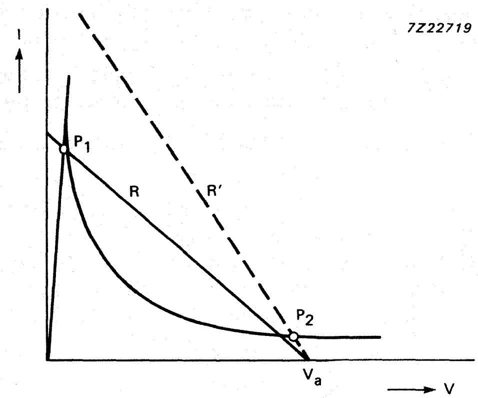


Fig.9 PTC thermistor in series with a load showing the influence of the load resistance.

Resetting resistance

When the PTC thermistor is switched i.e. its temperature rises above the switching temperature T_s, it can only return from P_2 to P_1 if the load line lies below the V/I characteristic curve. This means that:

1. either the supply voltage V_a decreases (at constant load resistance), see Fig.10, or
2. the load resistance increases (at constant voltage), see Fig.11.

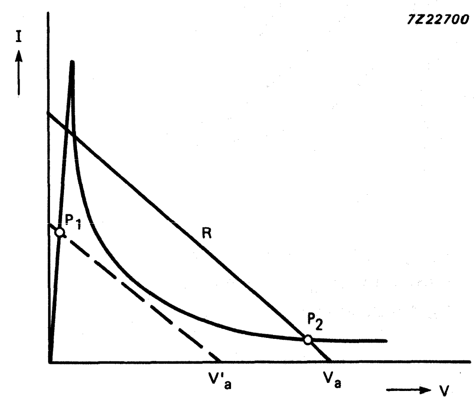


Fig.10 PTC thermistor in series with a load showing the influence of a decrease in supply voltage V_a.

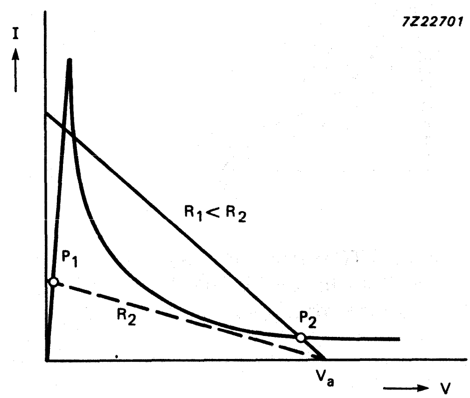


Fig.11 PTC thermistor in series with a load showing the influence of increased load resistance.

Note: When the temperature of the PTC thermistor is greater than T_s (i.e. the thermistor is in its tripped state), it will heat up causing the ambient temperature to increase (as shown in Fig.8). This must be taken into account when calculating the value of load resistance (i.e. the resistance of the PTC).

Current/time characteristics

If a PTC thermistor is connected in series with a resistance of such a value that the peak of the V/I curve lies under the load line, the PTC will heat up until the stable working point (P_2) is reached (see Fig.12). The time taken to reach this point is dependent on the value of load R (see Fig.13) and the ambient temperature.

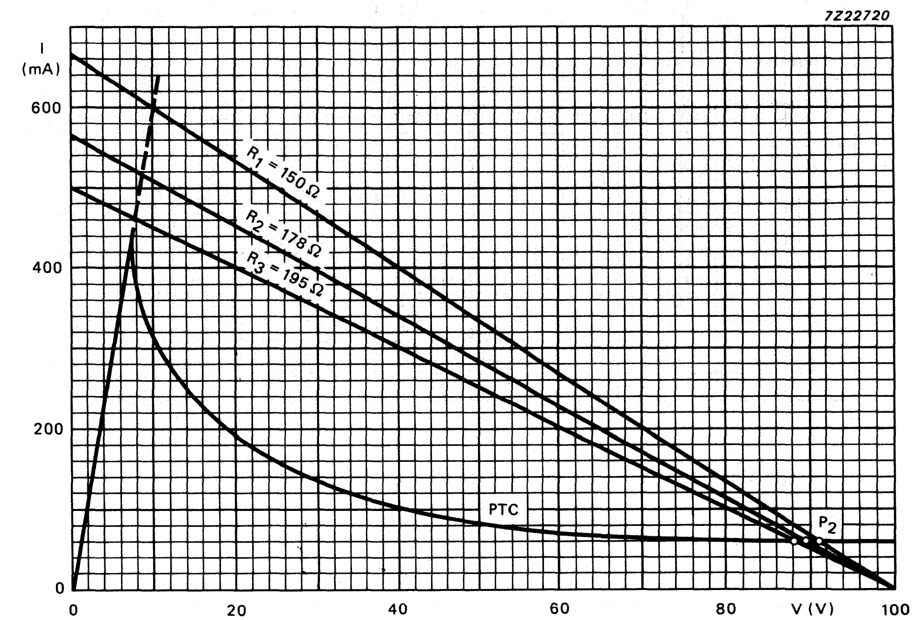


Fig.12 PTC thermistors in series with different resistors.

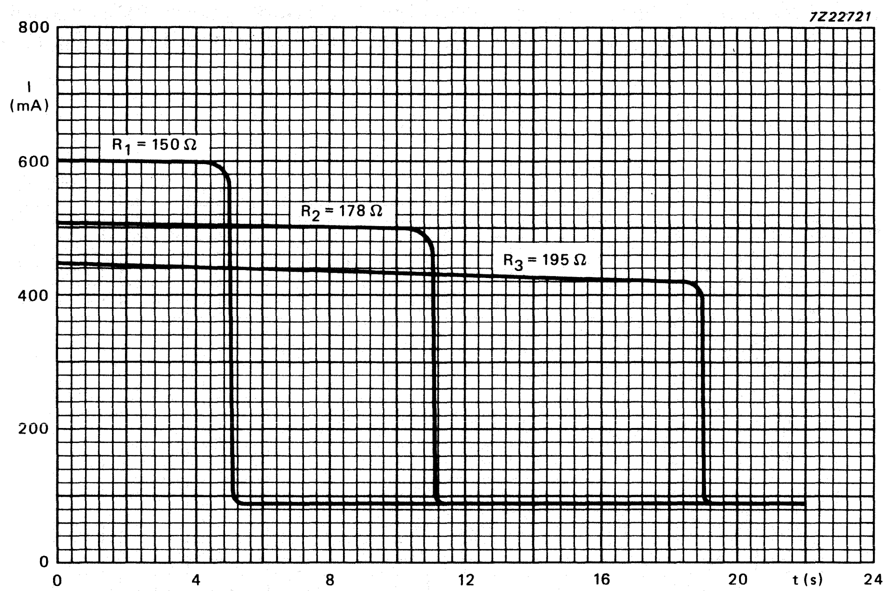


Fig.13 Current/time characteristics showing the influence of the load.

EXPLANATION OF TERMS

Switch temperature (T_s)

The switch temperature is the temperature at which the resistance R_s is equal to twice the minimum resistance R_{min} (see Fig.14), so at $T_s > T_{Rmin}$, $R_s = 2\ R_{min}$.

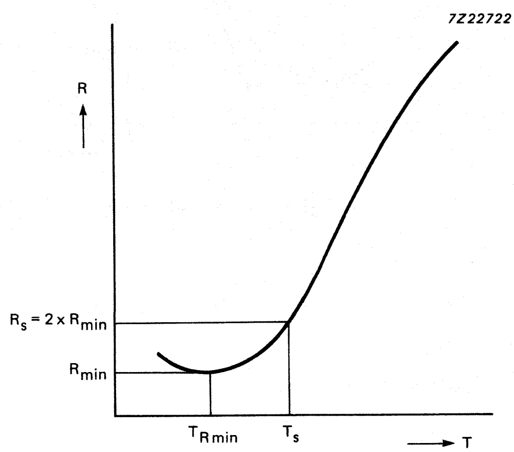


Fig.14 Switch temperature.

Temperature coefficient (α)

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

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

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

In the data sheets, the maximum temperature coefficient (α) is given; this is measured at the point of inflection of the log R-lin T characteristic, i.e. the point where $d^2 \log R/dT^2 = 0$ (see Fig.15).

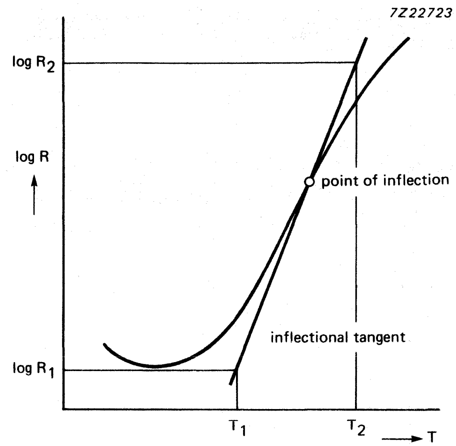


Fig.15 Temperature coefficient.

When one resistance decade is taken ($R_2 = 10\ R_1$), the formula becomes:

$$\alpha = \frac{100}{0.4343} \times \frac{1}{T_2 - T_1} \ \%/K$$

Trip time

The trip, or response time is defined as the time taken for the PTC thermistor to reach its switching temperature at a constant voltage. This time period is also equal to the time taken for the current to be reduced by a factor of 2.

The trip time (t_s) can be calculated using the formula:

$$t_s = \frac{h \,.\, v \,.\, (T_s - T_{amb})}{I_t^2 \,.\, R_{25} - D(T_s - T_{amb})}$$

where:

- v is the volume of the ceramic in mm^3
- R_{25} is the resistance at 25 °C
- I_t is the trip current
- the specific heat of the ceramic $h = 2.5 \times 10^{-3}$ J/°C/mm^3

Thermal time constant (τ)

The thermal time constant is the time required for a thermistor to convert 63.2% of the total difference between its initial and final body temperature when subjected to a step function change in temperature under zero power conditions.

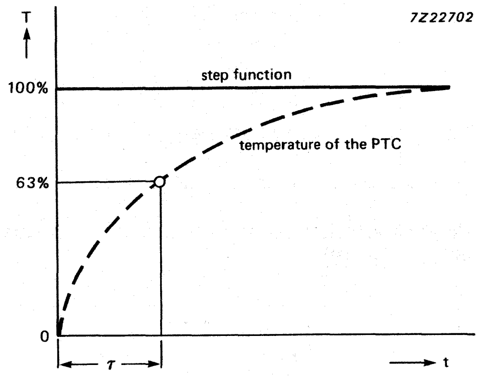


Fig.16 Thermal time constant.

Voltage dependence (VDR effect)

PTC thermistors exhibit voltage dependence. The higher the voltage applied, the more the R/T curve deviates from the R/T characteristic at 'zero voltage' (measured at a negligibly small voltage). This voltage dependancy can be demonstrated by applying a pulsed voltage to the thermistor and then measuring the R/T characteristic.

This effect can be explained with the aid of a parallel connection of an 'ideal PTC', having no voltage dependence, and an 'ideal VDR'.

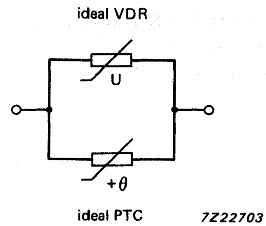


Fig.17 VDR effect.

Plotted on a log I — log V scale at an arbitrary constant temperature, the ideal PTC and the ideal VDR characteristics are straight lines (see Fig.18).

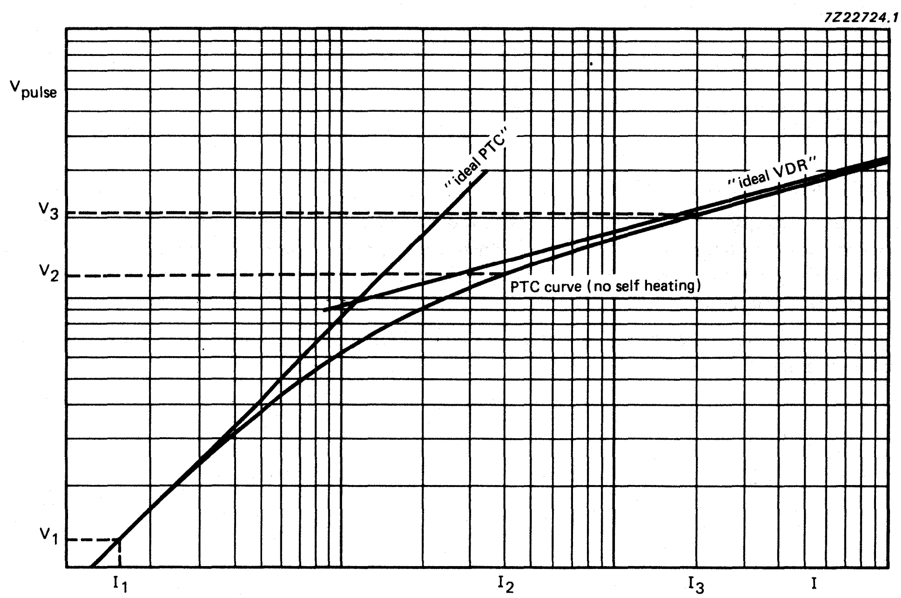


Fig.18 Relationship between an 'ideal PTC' and an 'ideal VDR'.

These lines coincide with the PTC curve (measured under pulse conditions to avoid internal heating) at low voltages where the ohmic behaviour is the deciding factor, and at high voltages where the VDR effect becomes more significant.

HOW TO MEASURE PTC THERMISTORS

Since PTC thermistors often exhibit a very high temperature coefficient, especially at high temperatures, measurement at high temperature must be carried out with particular care. Even an error of 0.1 K can give errors of a few percent in resistance value. Specially calibrated thermometers must be used. Stem correction must be applied – deviations of more than 0.1 K may result if it is not used.

The stem correction formula for fluid thermometers is:

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

where:

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

F is approximately equal to 0.00016 for a mercury thermometer.

Example

If T_o = 110 °C, T_m = 70 °C, and L = 50 K, substitution in the above formula will give the result, T_c = 110.32 °C.

Without stem correction, an error of more than 0.3 K would have been made.

Note: The resistance should be measured using a voltage of less than 2 V, in order to ensure that the PTC is not heated, and also to diminish voltage dependent effects.

Tolerances

The resistances of standard PTC thermistors are generally specified at

a. 25 °C
b. a temperature having a greater value than the switch temperature.

The switch temperature is quoted in the relevant data sheets.

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

Special types are often specified in accordance with the requirements for the particular application. For example, PTC's for motor control may be specified at a high temperature with a close tolerance, whilst the tolerance below the switch temperature, being of less importance, is much greater. PTC thermistors for current limiting applications are, in most instances, specified in terms of current and voltage.

IMPORTANT NOTES:

- the specification and tolerances of PTC thermistors depend to a great extent upon the application in which the device is to be used. They are not limited to the standard range detailed in this handbook.
- IF SPECIAL PTC CHARACTERISTICS ARE REQUIRED WHICH CANNOT BE FOUND IN THIS HANDBOOK, CONSULT THE MANUFACTURER SINCE REQUIREMENTS MAY BE FULFILLED BY A NON LISTED DEVICE.

APPLICATIONS

The applications for PTC thermistors can be divided into five main categories:

1. overload (current sensitive action)
2. degaussing
3. heating
4. motor start (e.g. compressors)
5. temperature sensing.

These applications are based on two principles:

a. applications where the temperature (hence the resistance) is primarily determined by the current flowing through the thermistor

b. applications where the temperature is primarily determined by the temperature of the ambient medium.

CAUTIONS

DO NOT APPLY A VOLTAGE ABOVE V_{MAX} TO THE PTC SINCE THIS MAY DESTROY THE THERMISTOR.

DO NOT CONNECT PTC THERMISTORS IN SERIES TO OBTAIN HIGHER VOLTAGES OR WATTAGES, SINCE THIS MAY CAUSE AN INDIVIDUAL PTC TO HEAT UP FASTER THAN THE OTHER(S), RESULTING IN TOO HIGH A VOLTAGE ACROSS THE PTC IN QUESTION.

APPLICATION EXAMPLES

1. Overload protection (current sensitive action)

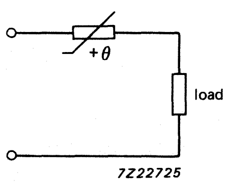


Fig.19 Current limiting.

Note

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

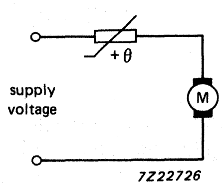


Fig.20 Protection of a stalled electric motor against overheating.

Note

The increased current heats the PTC to its switch temperature. As a result, the total dissipated power is reduced to a safe value. The example shown could also be used as protection against overheating in transformers, lamps, printed circuit boards, rechargeable batteries, power supplies etc.

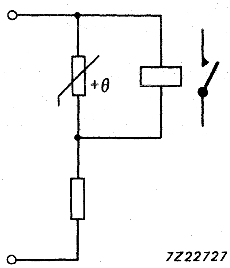


Fig.21 Delaying action of relays.

Note

After applying the voltage for a certain time period, the relay is activated.

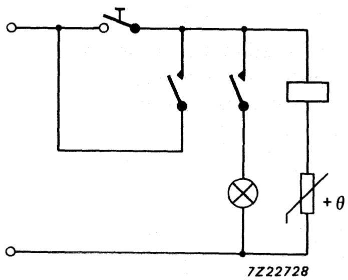


Fig.22 Time delay circuit.

Note

When the switch is operated, the relay is activated and the lamp is illuminated. After a certain time period, the relay is de-activated due to the increase in resistance of the PTC.

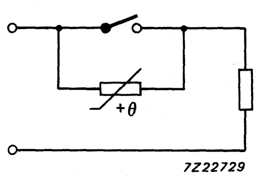


Fig.23 Spark suppression circuit.

Note

A PTC fitted in parallel with the switch acts as a spark suppressor. When the switch opens, the low resistance of the cold PTC prevents sparking.

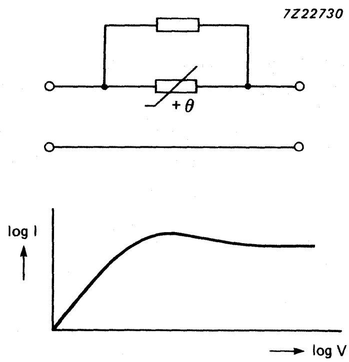


Fig.24 Current stabilization.

Note

By using a resistor fitted in parallel to the PTC, a current stabilization circuit is obtained that compensates slowly varying supply voltages.

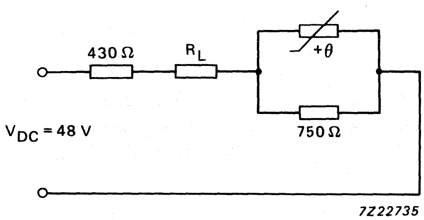


Fig.25 Line resistance (R_L) compensation.

One very useful application area is the use of this circuit to provide line resistance compensation for variations in telephone lines (see Fig.25).

2. Degaussing

Degaussing is the term given to the method employed to demagnetise the tube of a colour television to prevent colour impurities appearing on the screen. PTC's are used in conjunction with the degaussing coil. There are three possible circuit combinations:

- A single PTC in series with the degaussing coil (see Fig.26). This is known as a MONO degaussing PTC.
- Two PTC's may be used to reduce the final steady coil current to a very low value (see Fig.27). The second PTC acts as a heater to increase the resistance of the series PTC. This is known as a DUAL degaussing PTC.
- The heater action outlined above may also be achieved using a Negative Temperature Coefficient (NTC) thermistor to act as an inrush current limiting device, in conjunction with a PTC (see Fig.28). This is known as a P/N DUAL degaussing device.

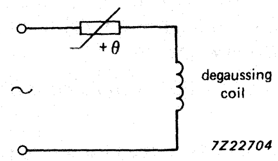


Fig.26 Mono PTC.

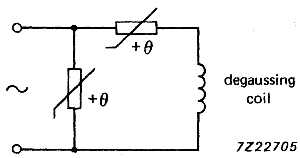


Fig.27 Dual PTC.

Note

The PTC's are thermally coupled.

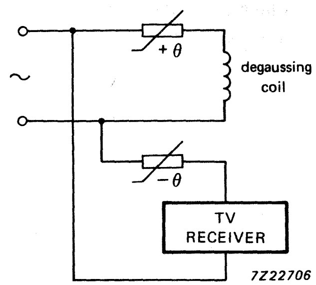


Fig.28 P/N dual device.

Note

The PTC and NTC are thermally coupled.

3. Heating

PTC thermistors may be used in a wide range of industrial, automotive and consumer heating applications, including bi-metal strips, soldering irons, fuel pre-heating, car mirror and doorlock defrosting, hair curling irons, warming plates etc.

The thermistors are particularly suitable for heating applications; they exhibit the following properties:

- the ceramic elements used are self-regulating; they do not require thermostats for limiting or stabilizing their temperature
- they heat up very quickly
- the power dissipated is virtually independent of the supply voltage
- they do not cause switch interference to the mains supply or other apparatus.

The behaviour of PTC heating elements cannot be easily concluded from the R/T or V/I characteristics, since the temperature of the element is not homogeneous during operation. In addition, the method of mounting has a considerable influence in a number of factors including dissipated power, the relevant temperature and the extent of power regulation.

A typical temperature profile across a heating element is shown in Fig.29.

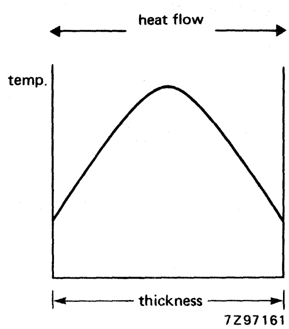


Fig.29 Typical temperature profile across a ceramic heating element.

Note

The uneven temperature profile across the ceramic is due to the cooling effect on the faces of the ceramic. This means that the inner temperature is higher than the temperature on the surface of the ceramic.

Heat transfer takes place from the inside to the outside of the ceramic.

It is possible to construct a thermal equivalent circuit of a PTC heating system. The properties of such a circuit may be considered when making calculations i.e. the thermal equivalent circuit becomes a 'simulator' for the actual circuit. Hence, this simulator may be used to provide an analysis of the proposed circuit.

Table 1 shows an analogy between electrical and thermal parameters and Fig.30 illustrates a thermal equivalent circuit.

Table 1 An analogy between electrical and thermal parameters

	electrical		thermal	
	parameter	unit	parameter	unit
parameters	resistance (R)	Ω	thermal resistance (R_{th})	K/W
	voltage (V)	V	temperature (T)	°C
	current (I)	A	power	W
	capacitance (C)	F	thermal capacity (H)	J/K
ohm's law (R, R_{th})	$R = V/I$		$R_{th} = T/P$	
differential equation (C, H)	$V = 1/C\int Idt$		$T = 1/H\int Pdt$	

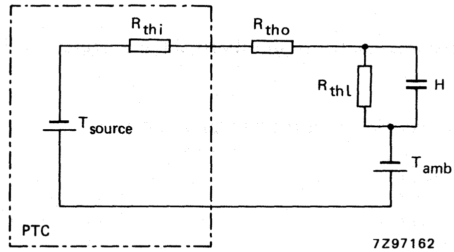


Fig.30 Thermal equivalent circuit.

Notes

1. T_{source} (°C) is approximately equal to T_s + 25 °C.
2. T_{amb} is the ambient temperature.
3. R_{thi} is the internal thermal resistance of the PTC. This value is mainly determined by:
   - dimensions of the ceramic
   - thermal conductivity of the ceramic (λ = 2.4 W/mK)
4. R_{tho} is the thermal resistance between the surface of the ceramic and the object to be heated, and is calculated from:
   - the thermal resistance between ceramic and isolator
   - the thermal resistance of the isolator
   - the thermal resistance between isolator and the object to be heated

   For optimum heating, the value of R_{tho} must be kept as low as possible.
5. R_{thl} is the thermal resistance of the object to be heated.
6. H is the thermal capacity of the object to be heated.

The thermal circuit shown in Fig.30 can be used to:

- perform simple calculations on the heating system due to the similarities between the equivalent circuit and the electrical circuit
- acquire an insight into the operation of a PTC thermistor
- predict the influence of certain parameters on the circuit.

The power dissipated in stable conditions may be calculated using the thermal equivalent of Ohm's law, i.e.:

$$P = \frac{T_{source} - T_{amb}}{R_{thi} + R_{tho} + R_{thl}} \quad (W)$$

The temperature of the object is:

$$T_1 = \frac{R_{thl}}{R_{thi} + R_{tho} + R_{thl}} \times [T_{source} - T_{amb}] + T_{amb} \quad (^oC)$$

The time constant of the system is:

$$H \times \frac{R_{thl} \times (R_{thi} + R_{tho})}{R_{thl} + R_{thi} + R_{tho}} \quad (s)$$

Characteristics of PTC heaters

The relationship of current against temperature and time is shown in Fig.31. It can be seen that the temperature rises to its working point (F) over a period of up to 20 minutes if mounted in a standard test jig.

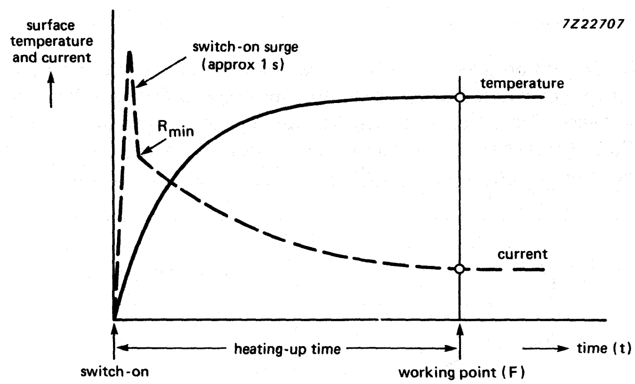


Fig.31 Surface temperature and current as a function of time for a PTC heater.

Note

At initial switch-on, the current will be high due to the low resistance of the PTC, but the current will gradually fall to a lower working level.

It can be seen from Fig.31 that, for normal mounting conditions, the initial current surge lasts for approximately 1 second, until the resistance value R_{min} is reached. The PTC heater then continues to heat up. The relationship between resistance and temperature is shown in Fig.32.

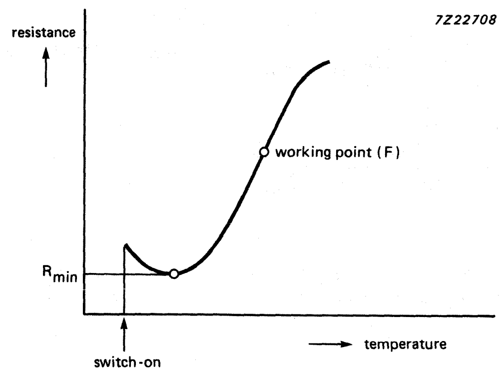


Fig.32 Resistance/temperature characteristic for a PTC heater.

The working point (F) should be selected to lie approximately half way up the slope of the R/T curve. The working point may be calculated using the temperature/power characteristic, which determines the heating power of the device. Provided the voltage is kept constant, it can be shown from the thermal equivalent circuit (Fig.30) and the formula for the calculation of power, that the temperature/power characteristic is linear as demonstrated in Fig.33.

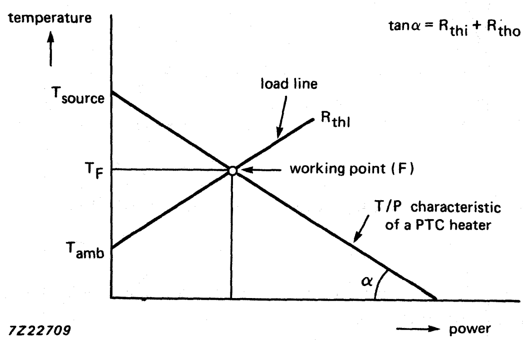


Fig.33 Temperature/power characteristic for a PTC heater.

The working point (F) is the intersection of the temperature/power characteristic with the load line expressing the thermal load R_{thl}. This load line is determined using the thermal version of Ohm's law:

$$R_{thl} = \frac{T_{source} - T_{amb}}{P}$$

The working point shown in Fig.33 shifts due to changes in ambient temperature, load variation and various mounting methods (see Figs 34, 35 and 36). For optimum heat transfer with respect to the thermal load, the T/P curve must be as near to the horizontal plane as feasible, i.e. the value of R_{tho} must be as small as possible (see Fig.36).

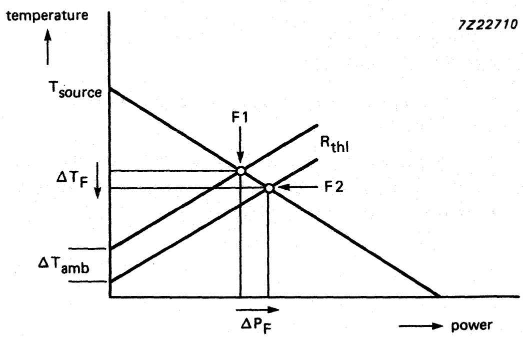


Fig.34 Influence of ambient temperature on working point.

Note

If the value of T_{amb} falls, the value of T_F falls and P_F increases.

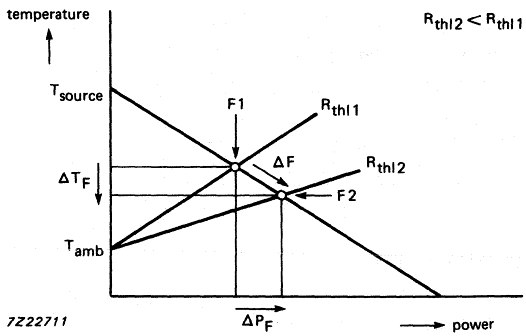


Fig.35 Influence of load variation on working point.

Note

If the value of the thermal resistance of the load falls, T_F falls and P_F increases.

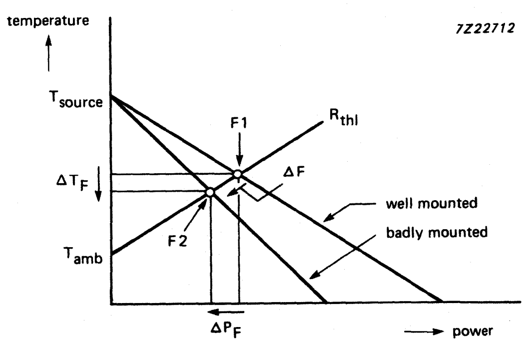


Fig.36 Influence of mounting method on working point.

Note

With bad mounting, R_{tho} increases so the T/P curve becomes steeper, the value of T_F falls and P_F increases.

It can be demonstrated from Fig.36 that the method of mounting ceramic or tubular assembled elements is very important. Obviously, mounting requirements vary from one user to another. The Applications Department is always available to advise on the best mounting methods for specific applications. However, for the most effective use of PTC heaters, it is essential that the thermal coupling is as efficient as possible.

With tubular assembled elements, the thermal coupling will also be affected by the characteristics and thickness of the materials used in the manufacture of the tubular mantle.

When an encapsulated heating element is mounted in an aperture which is too large, the thermal coupling will be poor, which results in a high value of R_{tho}.

When a heating element is not heavily loaded (e.g. in applications such as hair curlers, represented by line R_{thl1} in Fig.35), the influence of poor mounting is not so severe as if the system were heavily loaded (e.g. in applications such as oil burners, represented by line R_{thl2} in Fig.35).

Application examples

a. Heating plate.

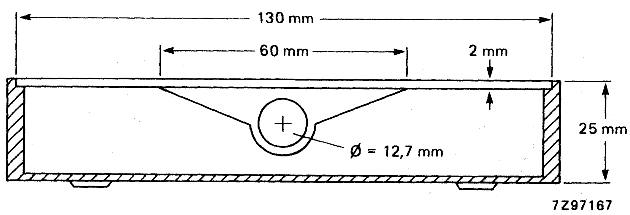


Fig.37 Heating plate.

Note

The aluminium plate measures 130 x 130 x 2 mm. The profile of the heating curves when subjected to a load is shown in Fig.38.

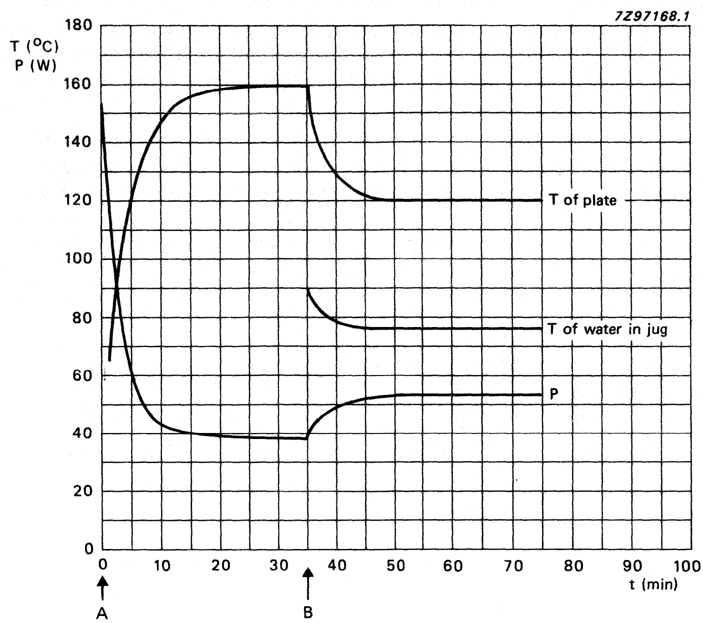


Fig.38 Profile curves of heating plate when subjected to a load.

Notes

Point A = heating plate switched on, unloaded.
Point B = loaded with pyrex jug containing 1 litre of water at 90 °C; ambient air temperature = 20 °C (constant).

b. Car door lock defrosting system.

A car door handle with a PTC heating element mounted on the lock mechanism is shown in Fig.39. A lever fitted behind the door handle activates a spring contact to connect the element to the car's 12 V supply. The flat PTC element is uninsulated and makes good thermal contact with a flat part of the lock close to the mechanism, ensuring that a rapid heating action will take place when the supply is connected.

As with all PTC devices, the dissipated power is at its greatest at low temperatures. However, for the majority of PTC's, there is a minimum resistance which remains constant in temperatures at, or below 0 °C. Hence, even in extreme environments, the maximum power dissipation is limited.

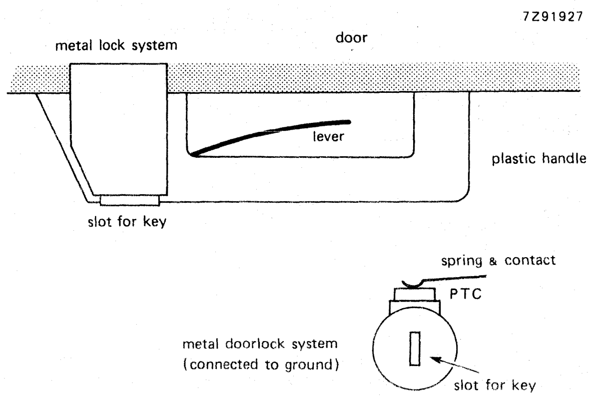


Fig.39 Car door lock defrosting mechanism using a PTC heating element.

c. Slim travel iron.

The iron, shown in Fig.40, uses four naked ceramic PTC heating elements mounted on an iron bottom plate. The thermistors are positioned such that the heat generated from both sides of each thermistor is transferred to the bottom plate (see Fig.41). The electric contacts are connected directly to the four thermistors, contributing to a fast warm-up time of the iron.

Measurements show a heating up time of 140 seconds to reach a temperature of 200 °C. Using a mains supply of 220 V RMS, the total current drawn is 260 mA. The flexibility of using PTC heating elements is further demonstrated by using a supply of 110 V RMS, which then gives a heating time to 200 °C of 210 seconds. The final temperature, after 20 minutes is approximately 220 °C.

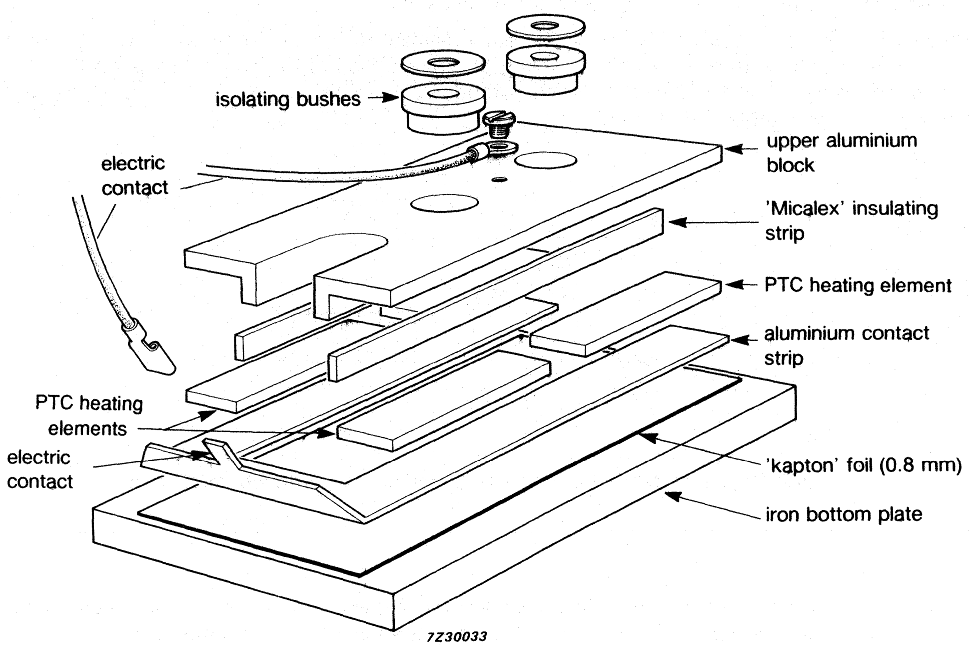


Fig.40 Travel iron using four PTC heating elements.

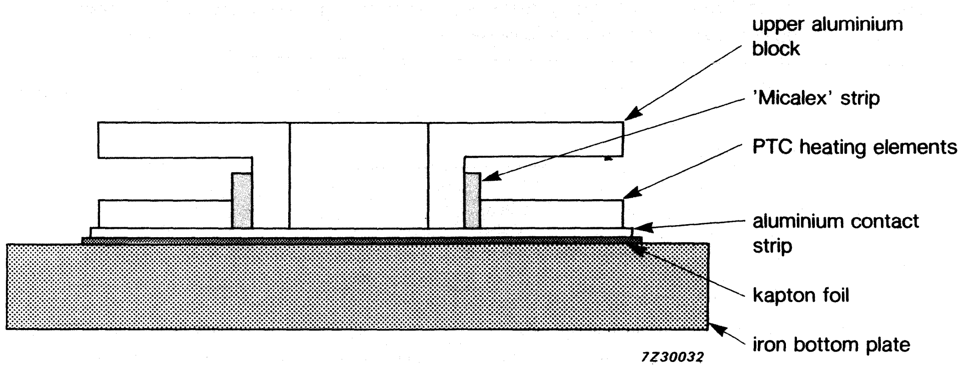


Fig.41 Cross section through iron showing method of connecting the PTC heating elements.

d. Circuit protection using a bi-metal strip heated by a PTC

A bi-metal strip may be equipped with a PTC heating element to construct a safety switch. The bi-metal used may be of the 'reset' type, so that, in effect, the combination of the bi-metal strip and PTC forms a switch with a memory, and allows galvanic separation between the switch and the PTC. If required, the switch may be remotely controlled.

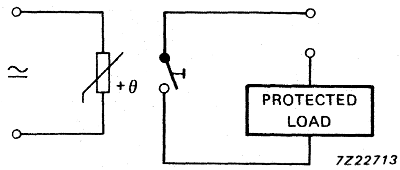


Fig.42 Circuit protection using a PTC in conjunction with a bi-metal strip.

4. Motor start

The following application is often used in situations where a quick response is required when starting motors, e.g. compressor motors for refrigerators, deep freezers and air-conditioning units.

To ensure a quick response time, these motors are often fitted with an extra winding which needs to be switched off once the steady state condition is attained. This extra winding is connected in series with a 'motor start' PTC (see Fig.43). During the start-up phase, extra current is delivered and the PTC gradually heats up, which causes an increase in its resistance and conversely, the current through the start-up winding is reduced to a negligible value.

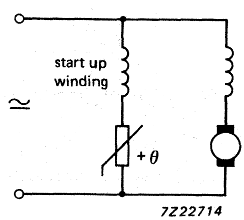


Fig.43 Use of a PTC in a fast start-up system.

5. Temperature sensing

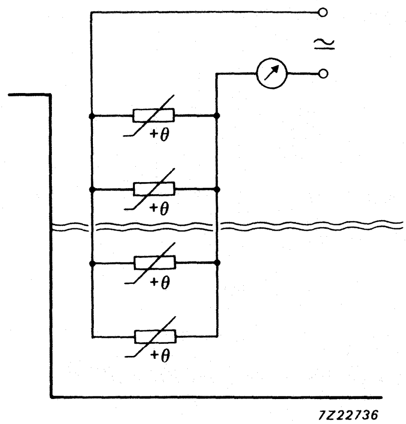


Fig.44 Liquid-level indication.

Note

The PTC thermistors located above the fluid level will be heated to a temperature greater than T_{switch}. When immersed they are cooled such that their resistance value is reduced.

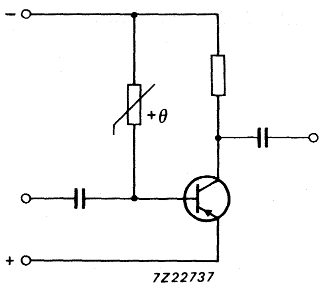


Fig.45 Temperature compensation of transistor circuits.

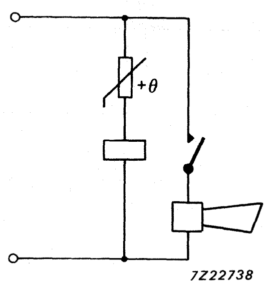


Fig.46 Alarm installation.

Note

The PTC reacts to ambient temperature (too low or too high)

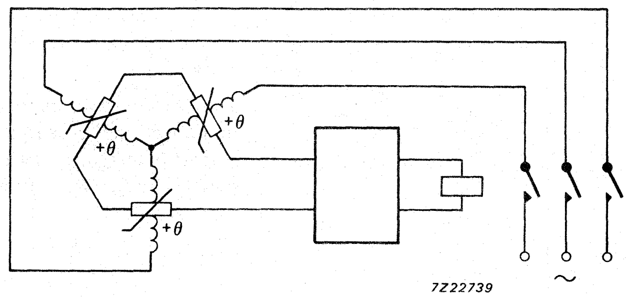


Fig.47 Temperature protection of electric motors.

Note

As soon as one or more of the windings becomes too hot, the motor is switched off.

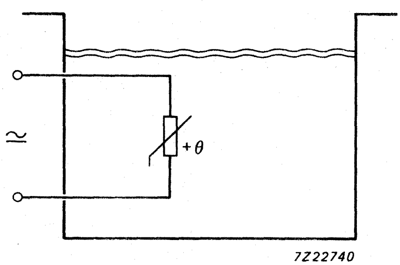


Fig.48 Thermostatically controlled heating circuit.

Note

The PTC thermistor acts as a control element and heater at the same time.

PTC HEATING ELEMENTS

Our programme of PTC heating ceramics is currently being updated and a new range of ceramics for heating will be available during 1990.

The range will be divided into two operating voltages:

– 265 V high voltage range
– 30 V low voltage range

The range will be available in a selection of switching temperatures in either rectangular or circular outlines. Figures 1 to 4 and Tables 1 to 3 show the outlines available and their dimensions.

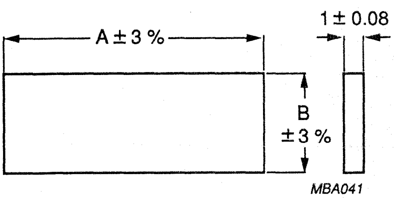


Fig.1 Rectangular outline, 30 V ceramic; see Table 1 for dimensions.

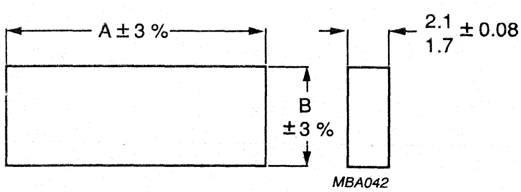


Fig.2 Rectangular outline, 265 V ceramic; see Table 1 for dimensions.

Table 1 Dimensions of rectangular ceramics

A (mm)	B (mm)
37	6
33	9
33	7
19	14
19	9
14	7
9	7

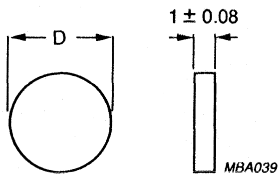


Fig.3 Circular outline, 30 V ceramic; see Table 2 for dimension D.

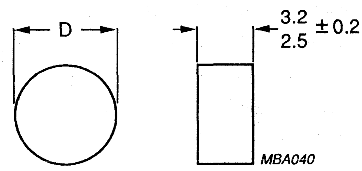


Fig.4 Circular outline, 265 V ceramic; see Table 3 for dimension D.

Table 2 Diameters available for 30 V circular ceramics

D (mm)
12.0
13.2
16.0
20.0

Table 3 Diameters available for 265 V circular ceramics

D (mm)
6.5
8.0
10.0
12.0

Table 4 shows an overview of the range which will be available.

Table 4 Range availability

Parameter	Outline availability for 30 V operation		Outline availability for 265 V operation	
	Rectangular	Circular	Rectangular	Circular
Switching temperature (T_s) (°C)				
60	Yes	No	Yes	No
80	Yes	Yes	Yes	No
100	Yes	No	Yes	No
120	Yes	Yes	Yes	No
140	No	No	No	Yes
160	Yes	No	Yes	Yes
200	Yes	Yes	Yes	Yes
220	Yes	No	Yes	No
240	Yes	No	Yes	No
Resistance range at 25 °C (R_{25})	2.5 to 17 Ω	1.5 to 4 Ω	250 Ω to 2.5 kΩ	800 Ω to 3.5 kΩ
Operating temperature range	–40 to + 85 °C		–20 to + 70 °C	

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 approximately
Temperature coefficient	+5%/K approximately
Max. voltage at T_{amb} = +55 °C	25 V d.c.
Dissipation factor	6 mW/K approximately
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +55 °C

APPLICATION

Temperature compensating and temperature measurement purposes.

DESCRIPTION

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

MECHANICAL DATA

Outlines

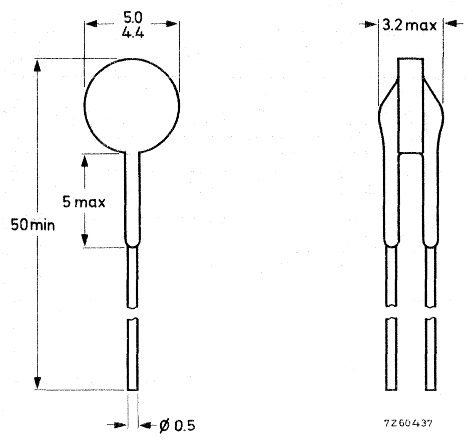


Fig. 1.

Mass 0,3 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength	10 N
Bending	5 N

Soldering

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

ELECTRICAL DATA

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

PACKAGING

500 thermistors in a cardboard box.

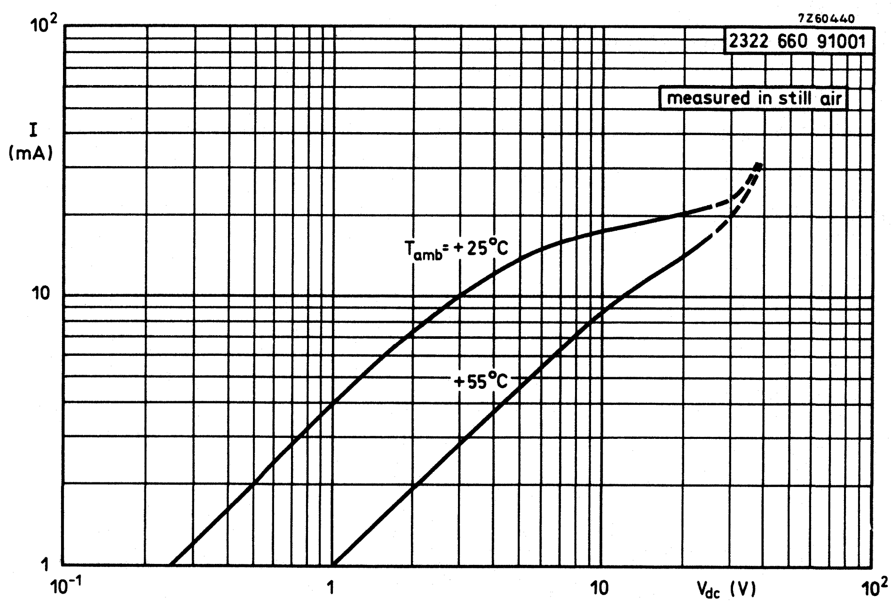


Fig. 2 Typical current/voltage characteristics.

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

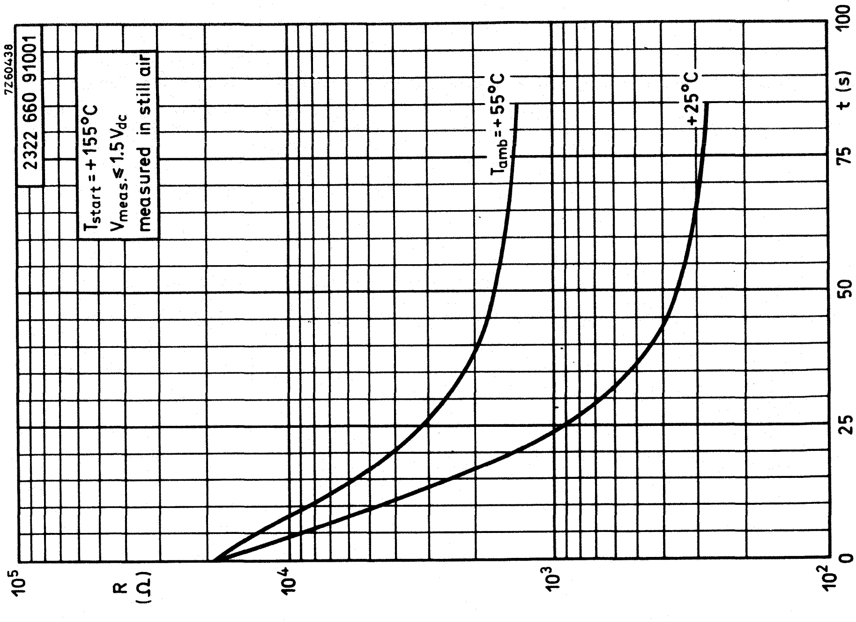


Fig. 4 Typical resistance/time (cooling) characteristics.

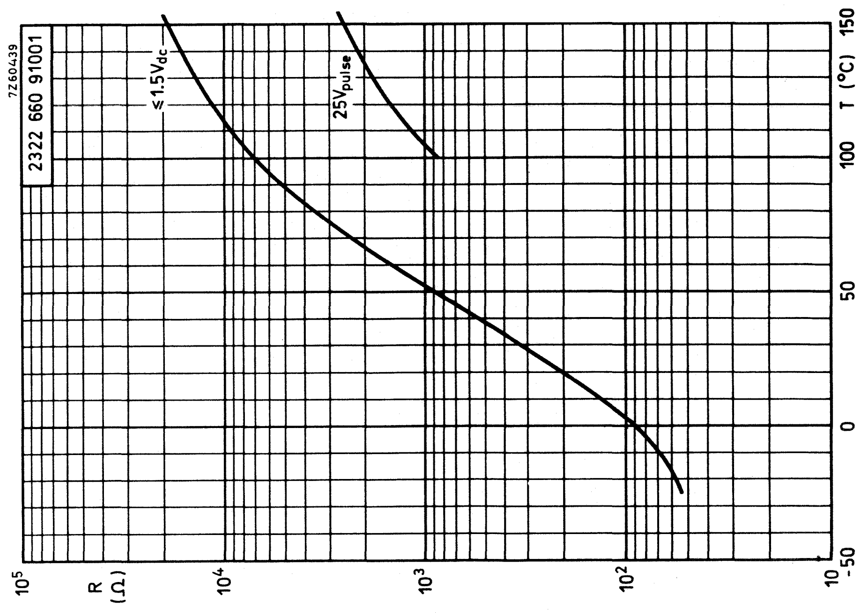


Fig. 3 Typical resistance/temperature characteristics.

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 (DC)	25 V
Dissipation factor	7 mW/K approximately
Operating temperature range	
at zero power	−25 to +125 °C *
at V_{max}	0 to +55 °C

MECHANICAL DATA

Outlines

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

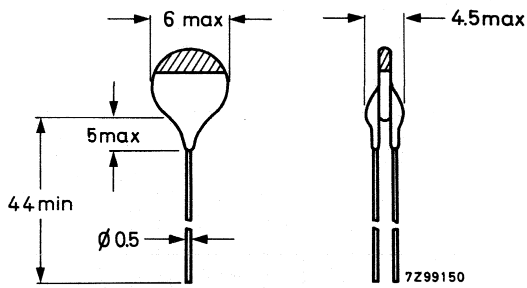


Fig. 1.

APPLICATION

General purpose.

DESCRIPTION

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

Marking

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

Mass 0,4 g approximately

Mounting In any position by soldering

PACKAGING

500 thermistors in a cardboard box.

* Type 2322 660 91009: −25 to +150 °C.

ELECTRICAL DATA

	catalogue number 2322 660 followed by 91006	91007	91008	91009	
Resistance *					
at 25 °C	60	50	50	50	Ω
at 125 °C	3 to 15	100 to 500	50 to 500		kΩ
at 150 °C				0,1 to 1,2	MΩ
Switch temperature	30	50	80	105	°C
R_{max} at T_s	100	300	400	400	Ω
Temperature coefficient	7	16	23	40	%/K
Heat capacity **	0,13	0,13	0,13		J/K
Thermal time constant **	20	18	18		s

Tolerance on R_{25} ± 30%

Max. voltage (DC) 25 V

Dissipation factor 7 mW/K approximately

Operating temperature range

→ at zero power −25 to + 125 °C ▲

at V_{max} 0 to +55 °C

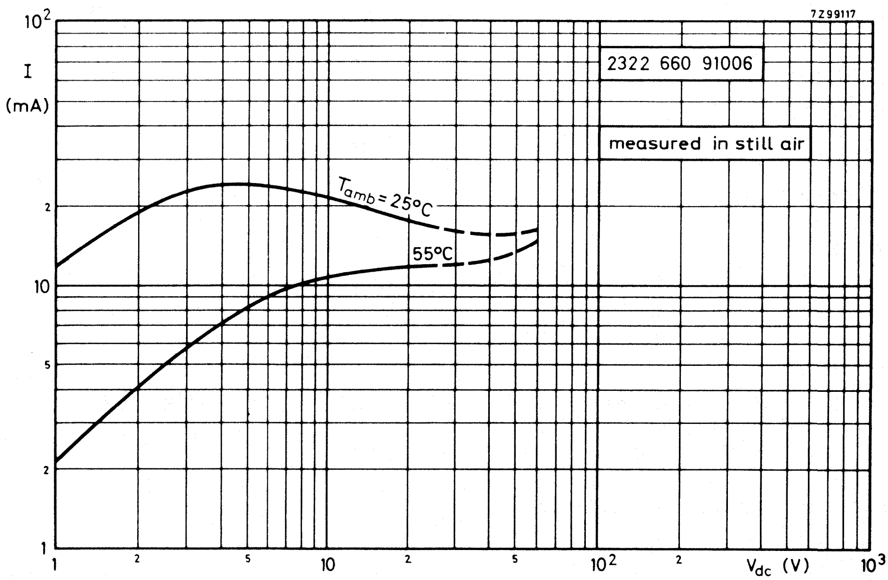


Fig. 2 Typical voltage/current characteristics.

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

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

→ ▲ Type 2322 660 91009: −25 to + 150 °C.

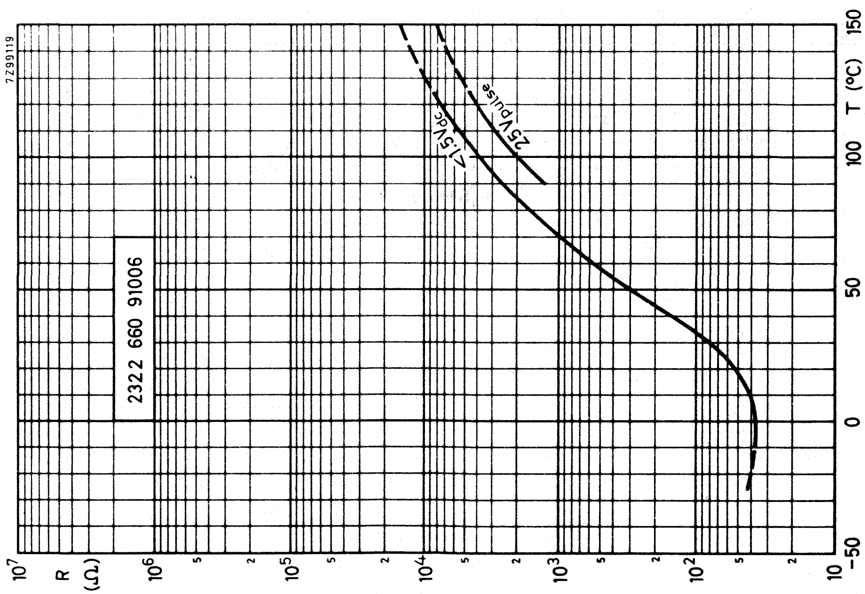


Fig. 3 Typical resistance/temperature characteristics.

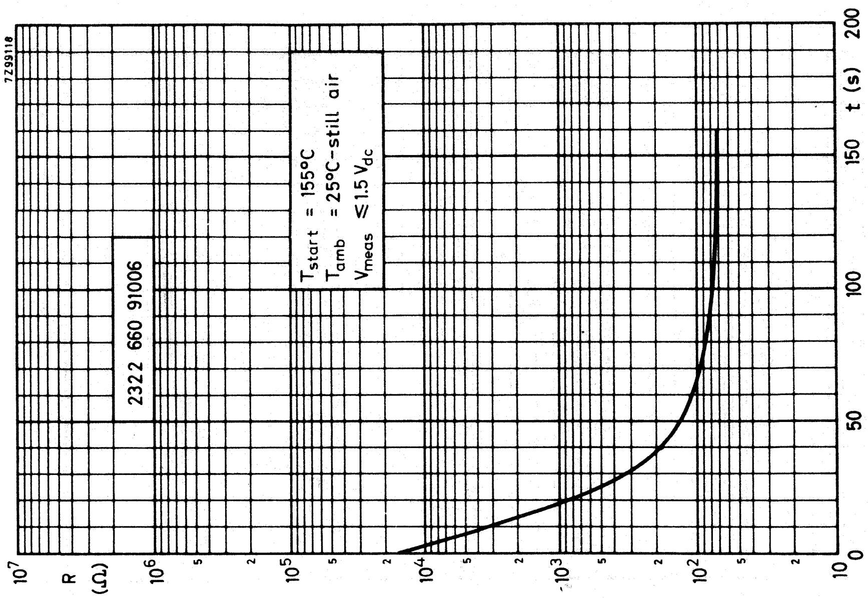


Fig. 4 Typical resistance/time (cooling) characteristic.

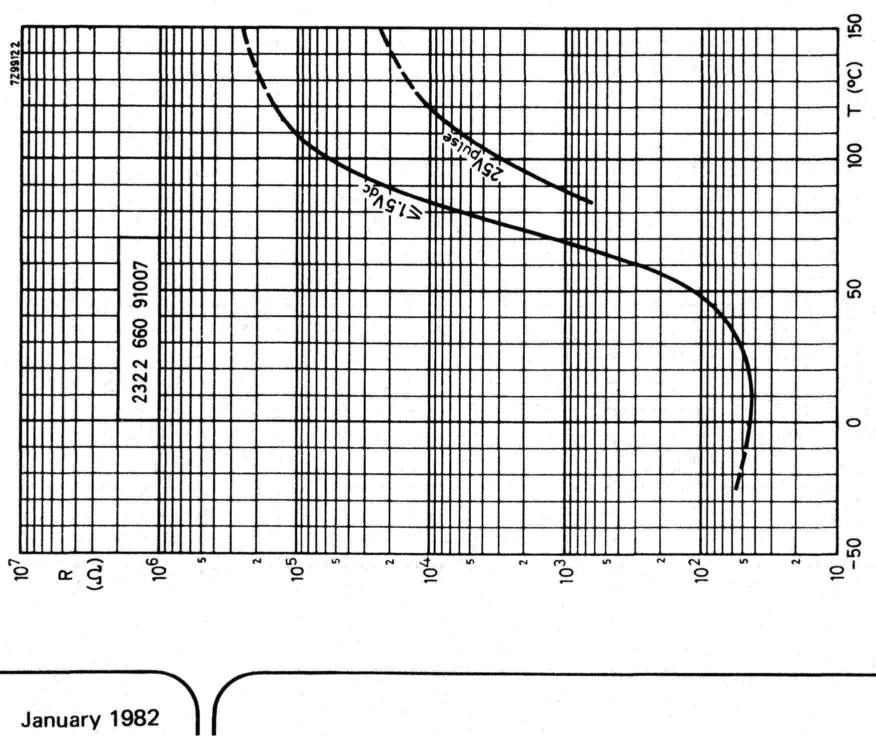


Fig. 5 Typical resistance/temperature characteristics.

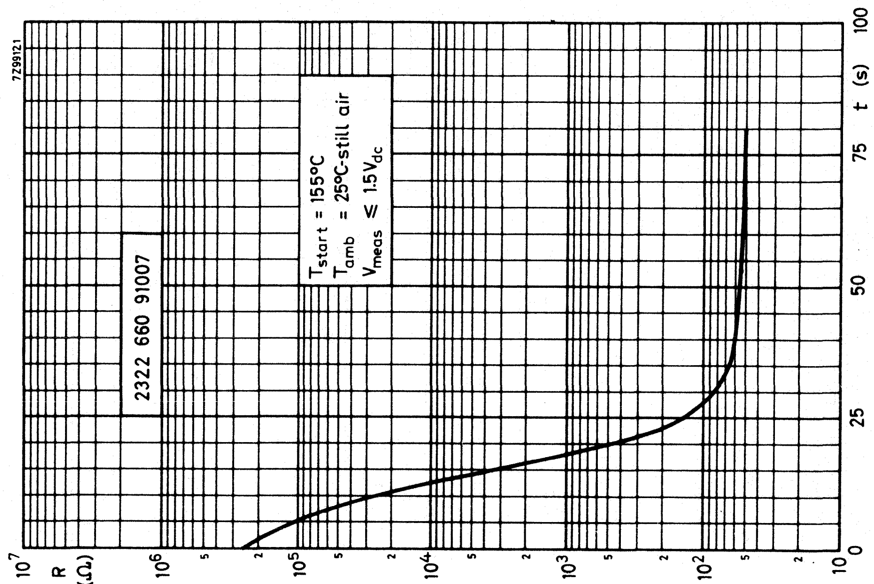


Fig. 6 Typical resistance/time (cooling) characteristic.

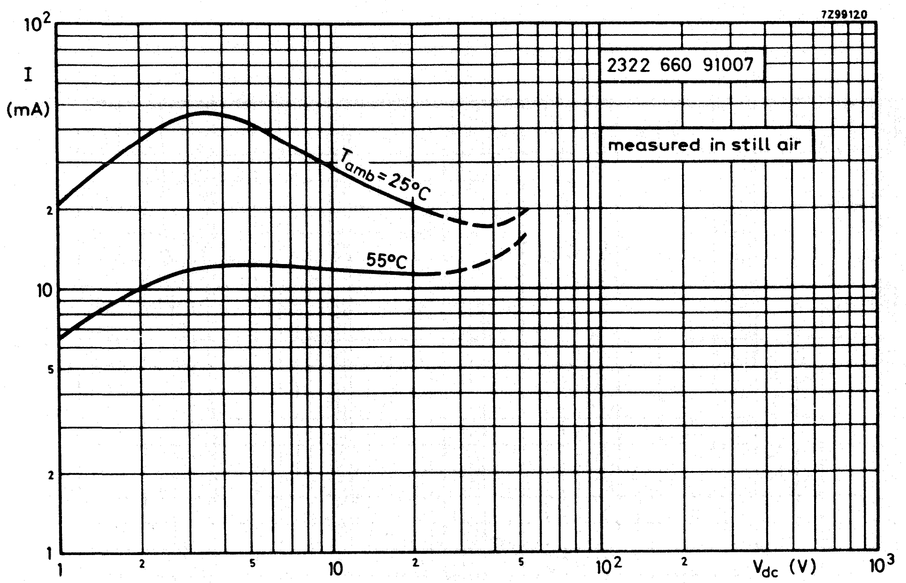


Fig. 7 Typical voltage/current characteristics.

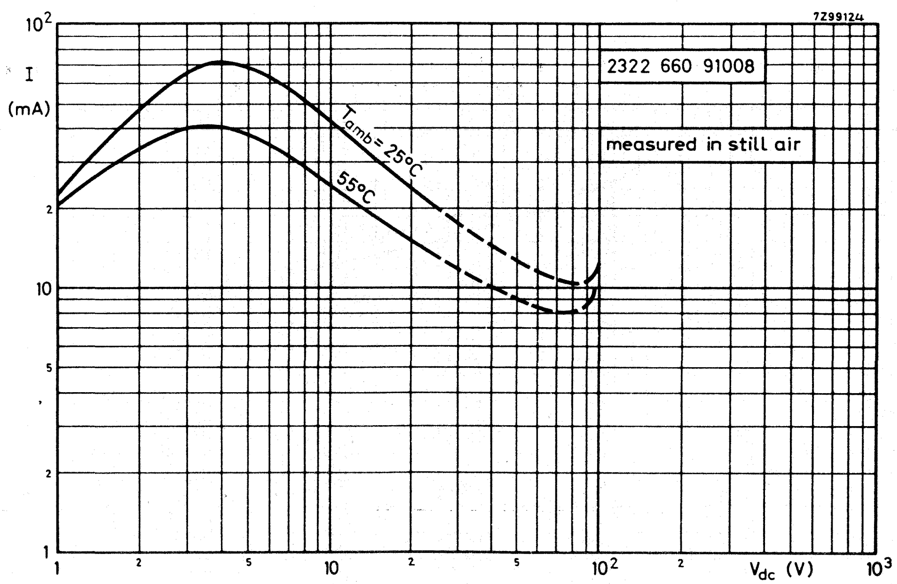


Fig. 8 Typical voltage/current characteristics.

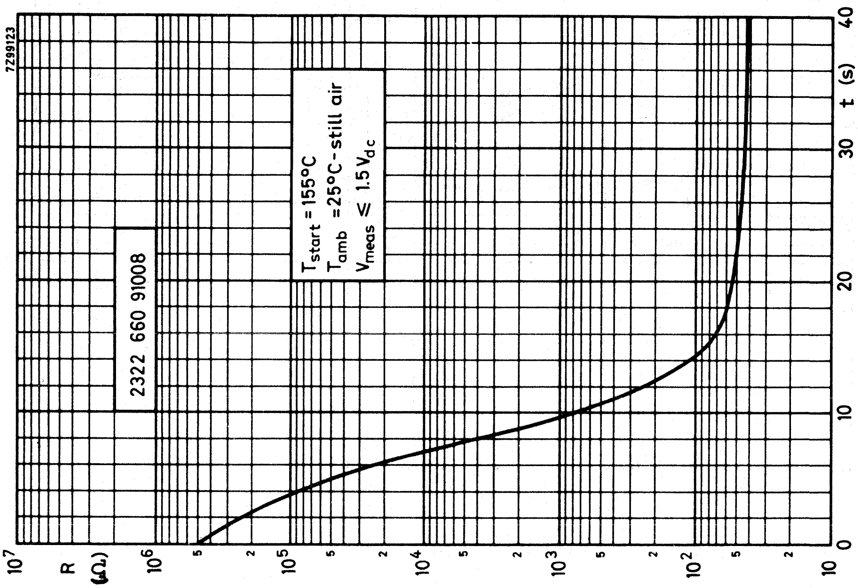


Fig. 10 Typical resistance/time (cooling) characteristic.

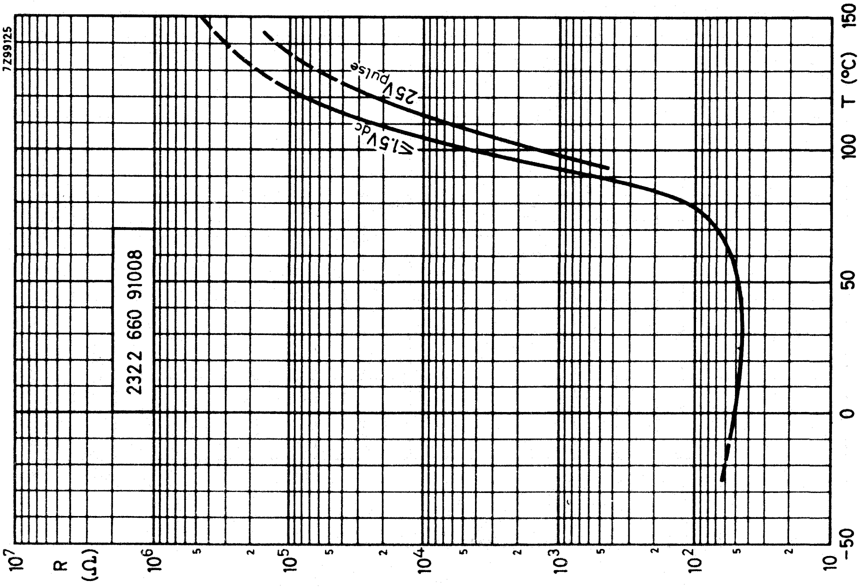


Fig. 9 Typical resistance/temperature characteristics.

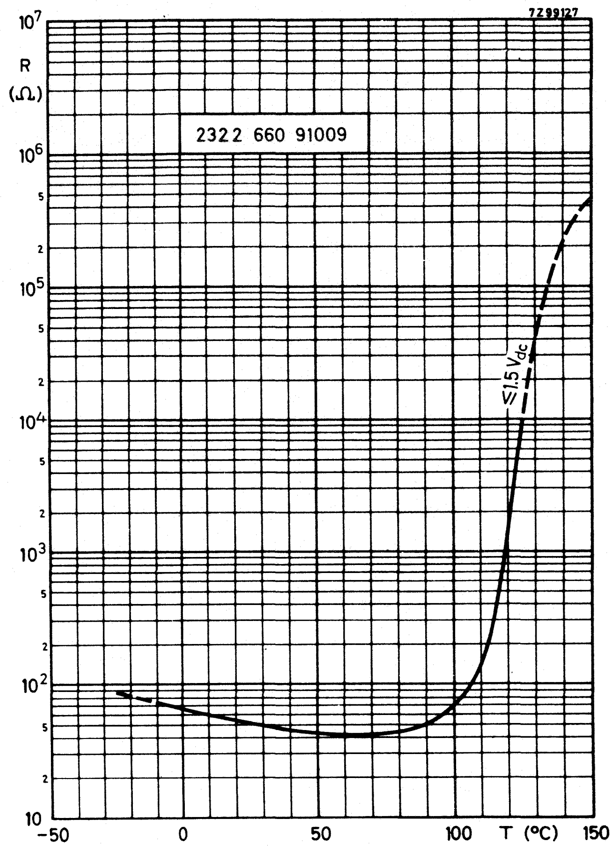


Fig. 11 Typical resistance/temperature characteristic.

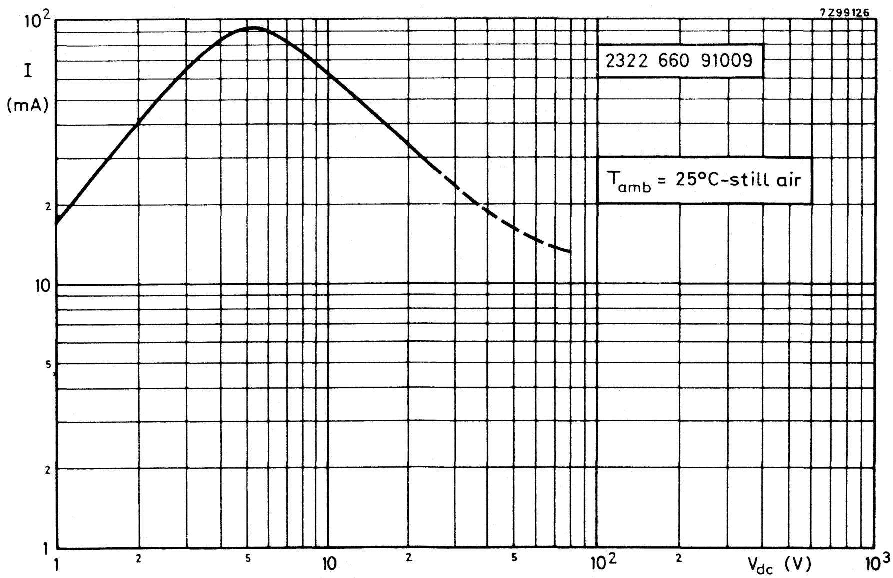


Fig. 12 Typical voltage/current characteristic.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

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

APPLICATION
General purpose.

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

MECHANICAL DATA
Outlines

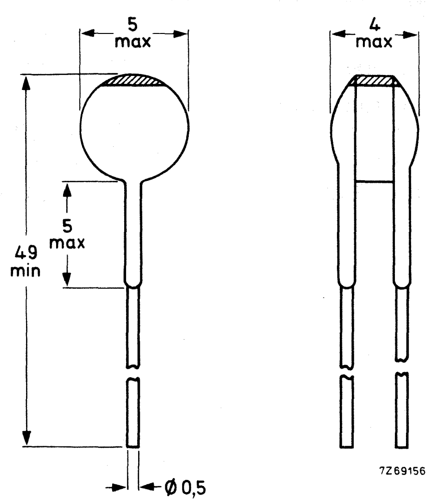


Fig. 1.

PACKAGING
500 thermistors in a cardboard box.

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

ELECTRICAL DATA

→ Unless otherwise specified measured according to IEC draft publication 40 (secretariat) 355.
All values without further indication are approximate values.

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

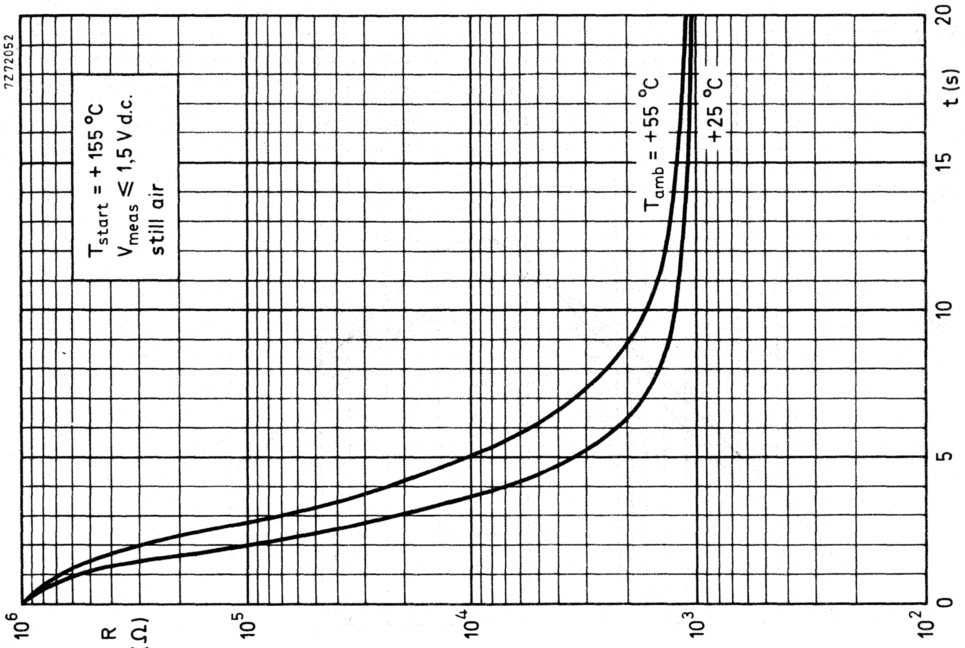


Fig. 3 Typical resistance/time (cooling) characteristics.

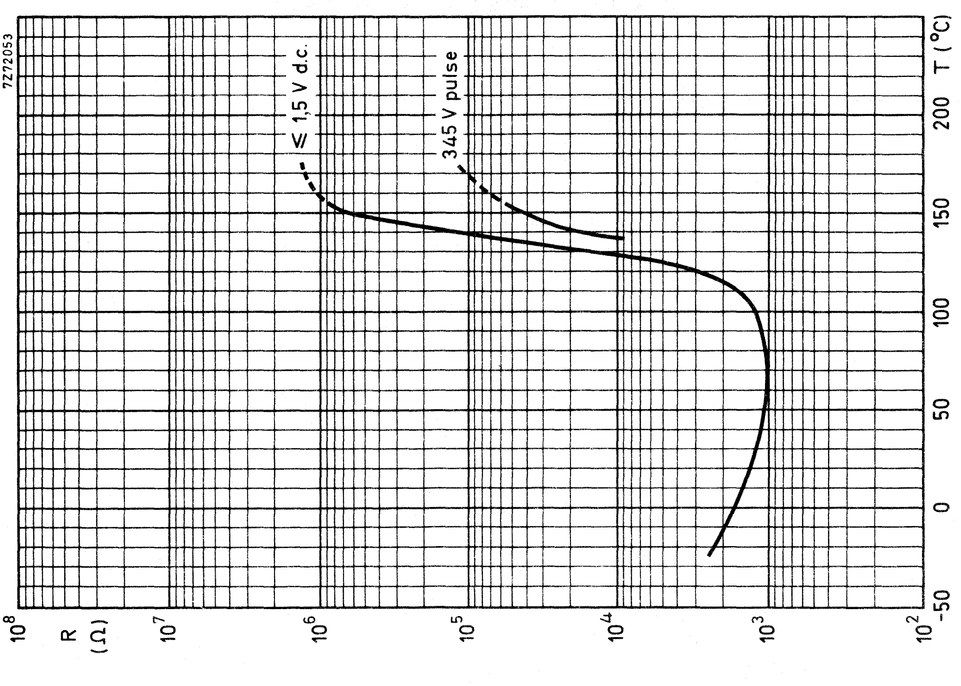


Fig. 2 Typical resistance/temperature characteristics.

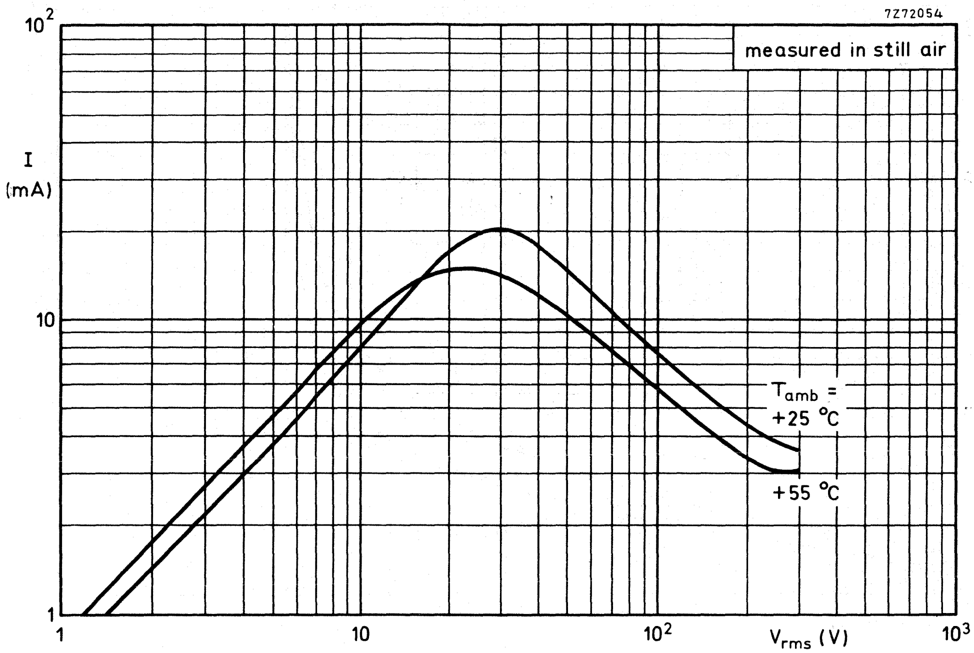


Fig. 4 Typical voltage/current characteristics.

PTC THERMISTORS

disc

QUICK REFERENCE DATA

Resistance value at + 25 °C	30 to 50 Ω
Resistance at other temperatures Switch temperature Temperature coefficient	See Table 2
Operating temperature range	
at zero power	−25 to + 125 °C
at V_{max}	0 to + 55 °C

APPLICATION

General purpose.

DESCRIPTION

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

MECHANICAL DATA

Outlines

Table 1

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

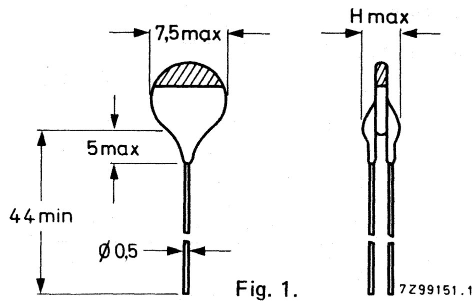


Fig. 1.

Marking

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

Mass 1 g approximately

Mounting In any position by soldering

Robustness of terminations

Tensile strength 10 N
Bending 5 N

Soldering

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

PACKAGING

500 thermistors in a cardboard box.

ELECTRICAL DATA

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

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

Tolerance on R_{25} ± 15 Ω

Operating temperature range
- → at zero power: −25 to + 125 °C
- at V_{max}: 0 to + 55 °C

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

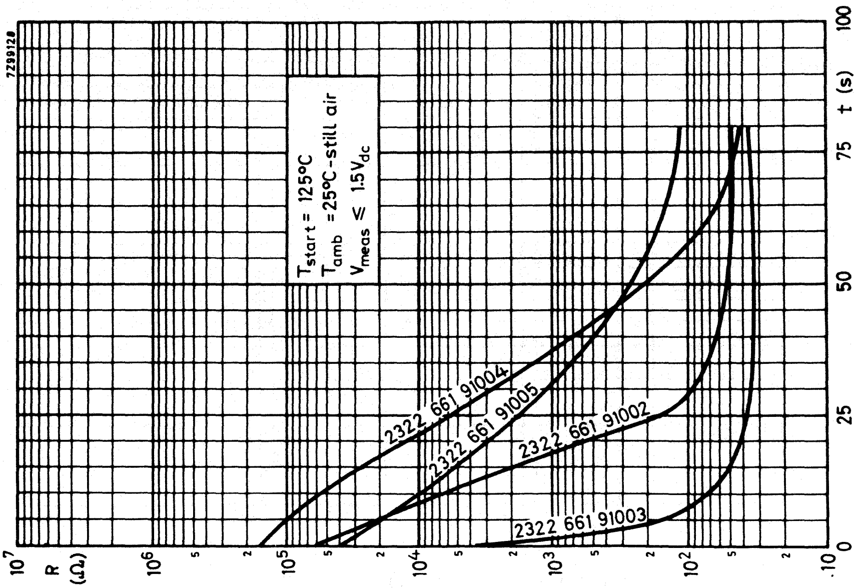


Fig. 3 Typical resistance/time (cooling) characteristics.

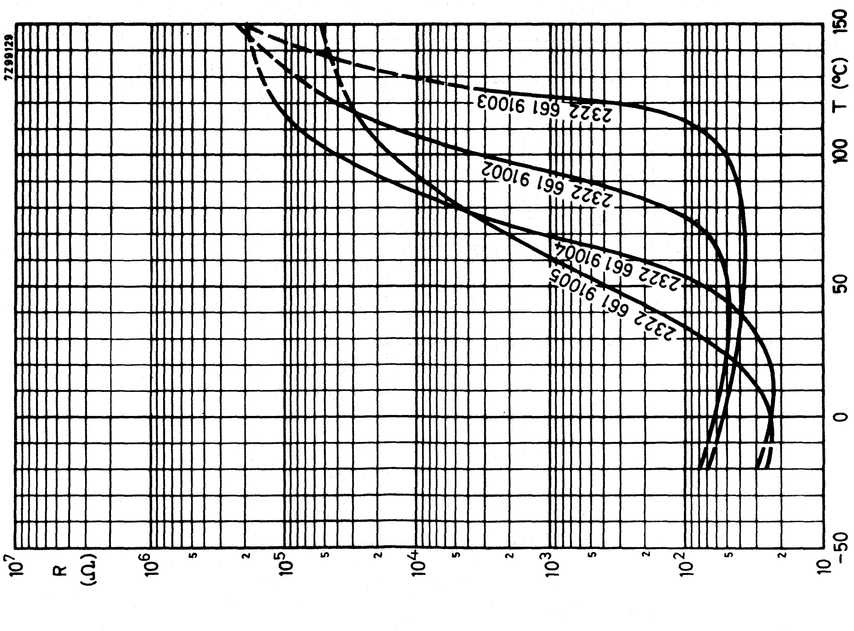


Fig. 2 Typical resistance/temperature characteristics.

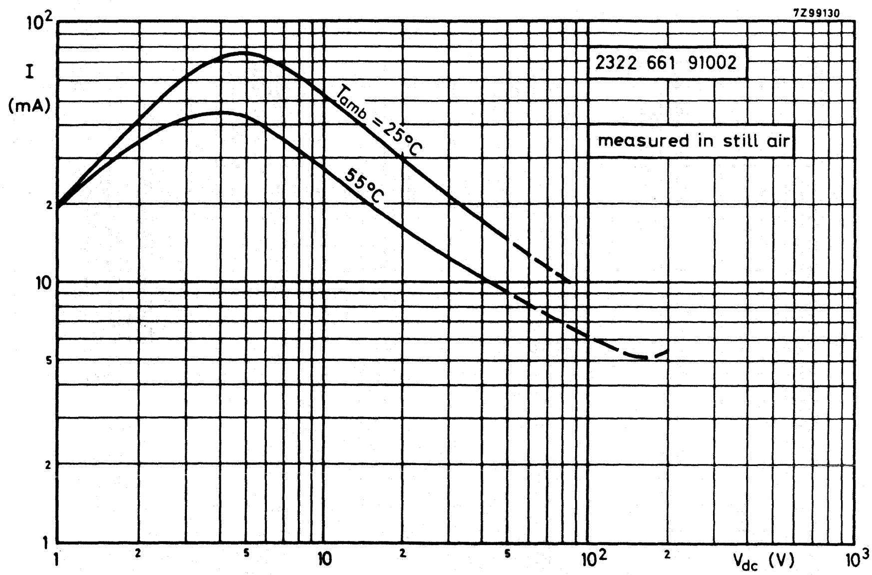


Fig. 4 Voltage/current characteristics.

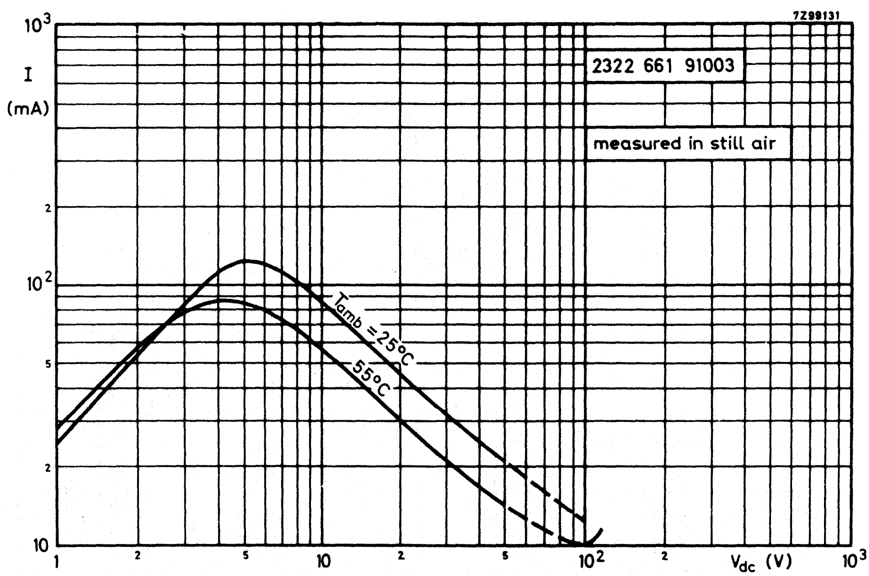


Fig. 5 Voltage/current characteristics.

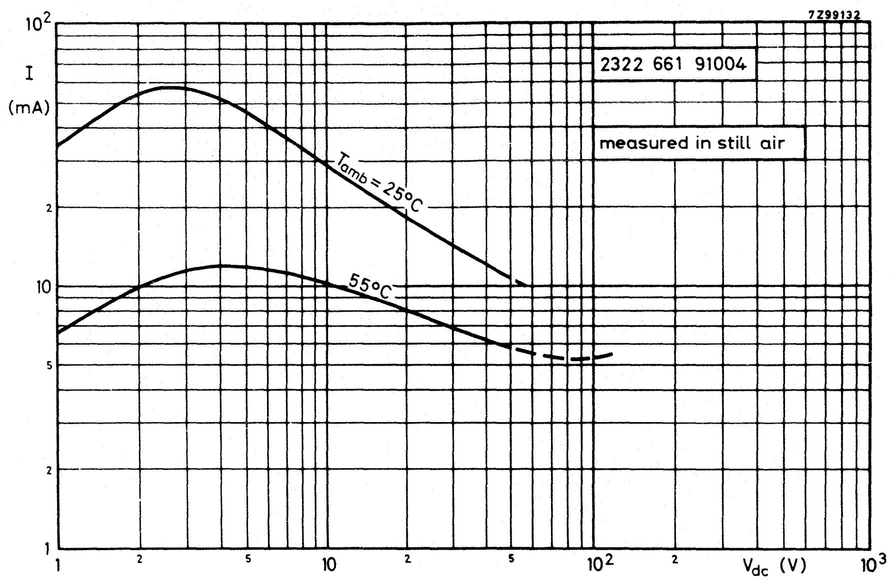


Fig. 6 Voltage/current characteristics.

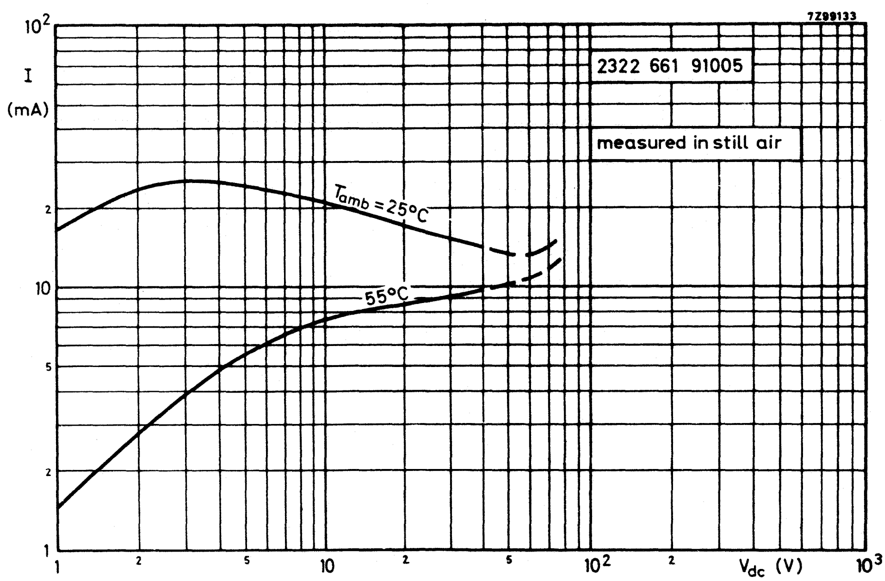


Fig. 7 Voltage/current characteristics.

PTC THERMISTOR

disc

QUICK REFERENCE DATA

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

APPLICATION

Protection of telegraphy relay contacts.

DESCRIPTION

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

MECHANICAL DATA

Outlines

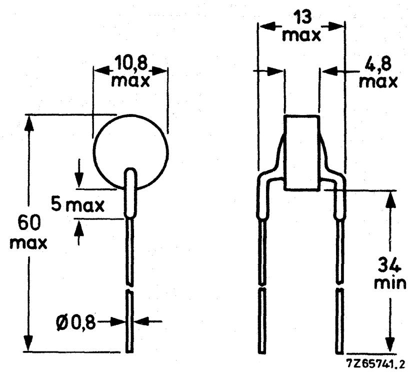


Fig. 1 Component outline.

Mass 2.27 g approximately

Mounting In any position by soldering

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

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

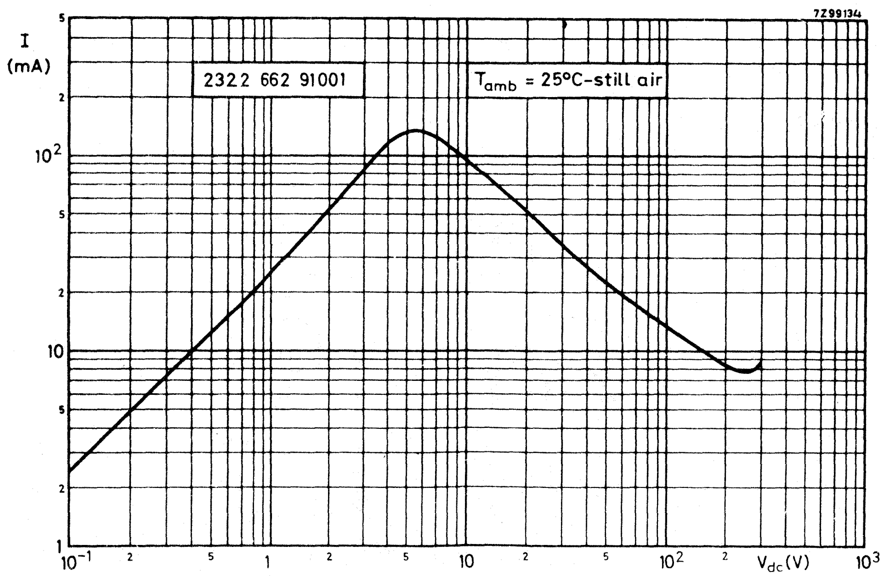


Fig. 2 Typical voltage/current characteristic.

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

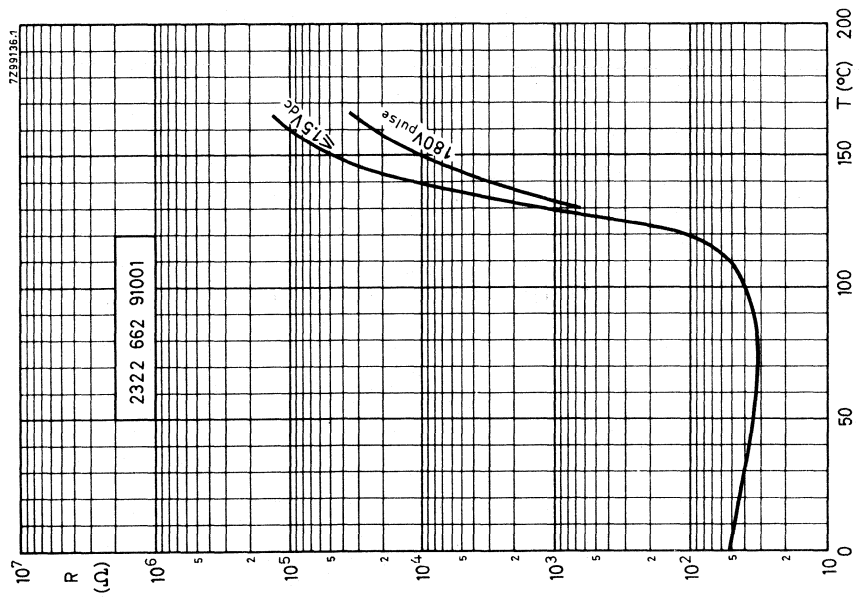


Fig. 3 Typical resistance/temperature characteristics.

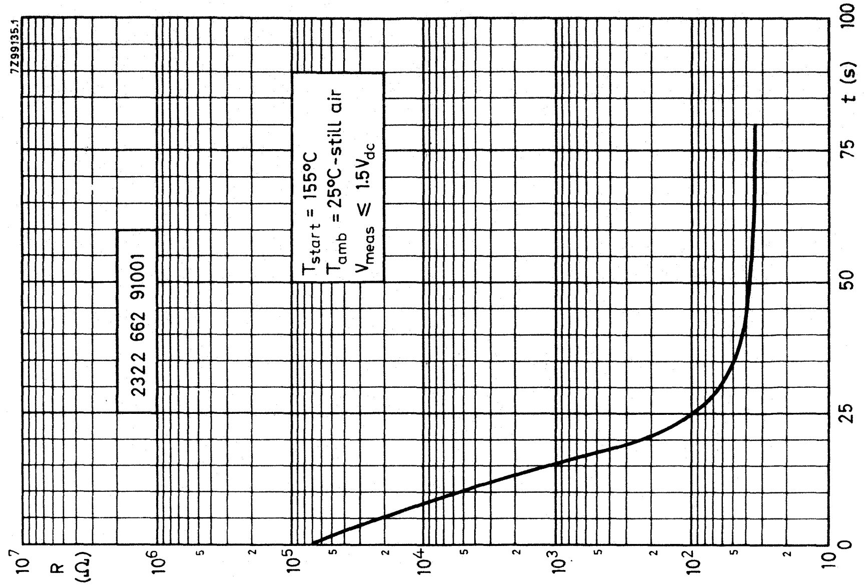


Fig. 4 Typical resistance/time (cooling) characteristic.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

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

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

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

MECHANICAL DATA
Outlines

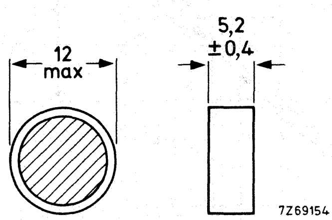


Fig. 1. Component outline.

Marking	None
Mass	2,7 g approximately
Mounting	In any position by clamping
Impact	200 mm free fall
Inflammability	The thermistors are non-flammable

PACKAGING
Plastic blister pack containing 320 items.

ELECTRICAL DATA

All values 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 RMS and +25 °C (measurement made without internal heating)	5 mA
Switch temperature	+120 °C
Temperature coefficient	+35%/K
Dissipation factor	11,5 mW/K
Heat capacity	1,3 J/K
Thermal time constant	115 s
Operating temperature range	
at zero power	−25 to +175 °C
at maximum voltage	0 to +85 °C
Maximum RMS voltage with series resistor of 300 Ω	460 V

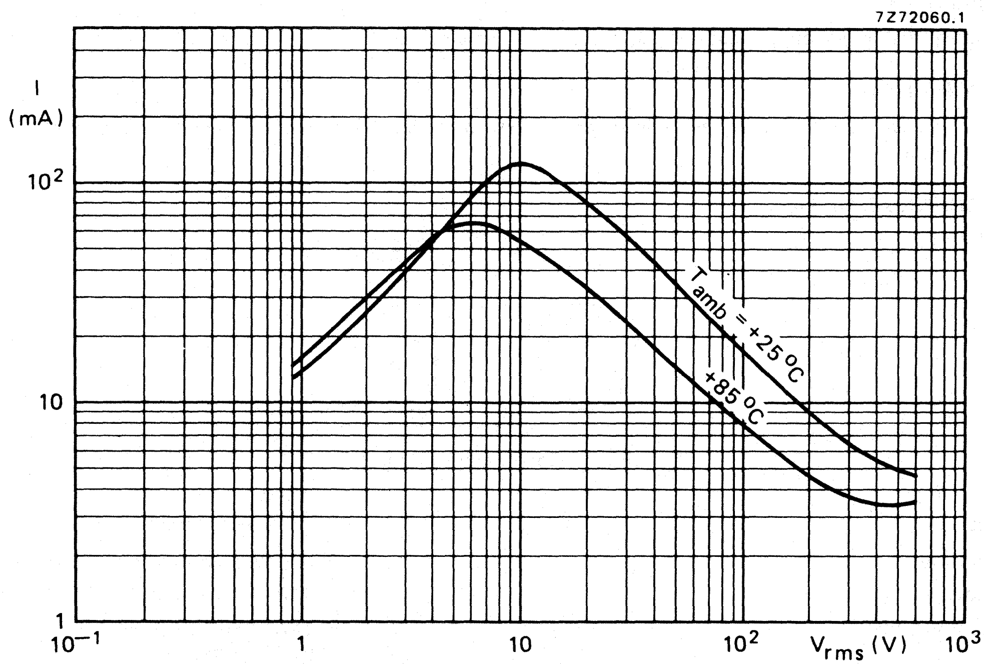


Fig. 2 Typical voltage/current characteristics.

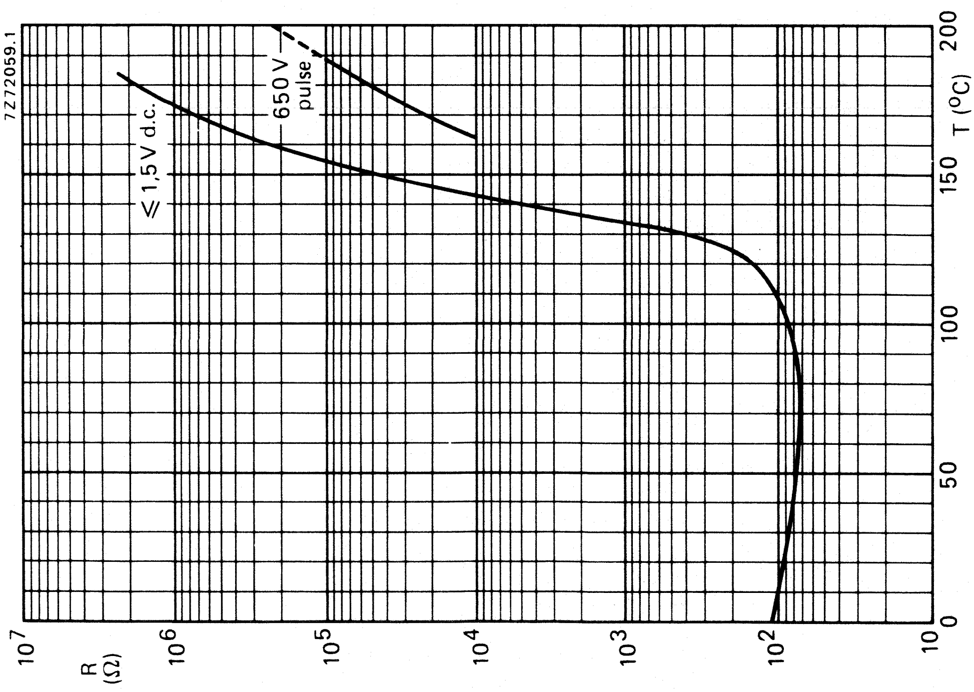


Fig. 2 Typical resistance/temperature characteristics.

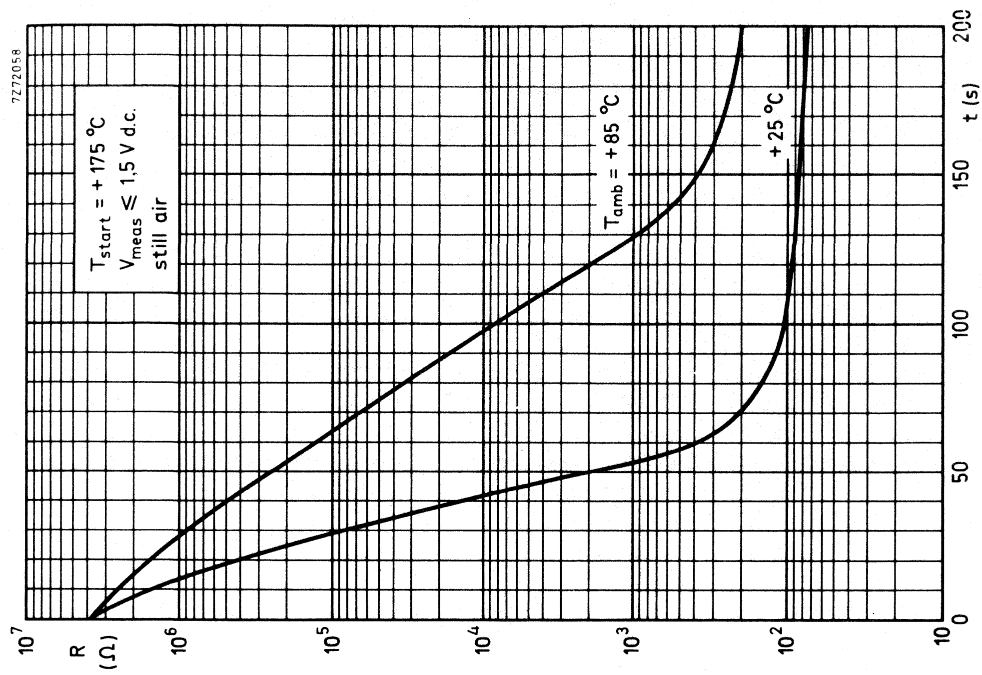


Fig. 3 Typical resistance/time (cooling) characteristics.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

Resistance value	
at +25 °C	45 to 60 Ω
at +150 °C	
V_{pulse} = 340 V	> 45 kΩ
Switch temperature	+75 °C approximately
Temperature coefficient	+20%/K approximately
Max. RMS voltage at $T_{amb} \leqslant 60$ °C	265 V
Dissipation factor	20 mW/K approximately
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	0 to +60 °C

APPLICATION

General purpose.

DESCRIPTION

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

MECHANICAL DATA

Outlines

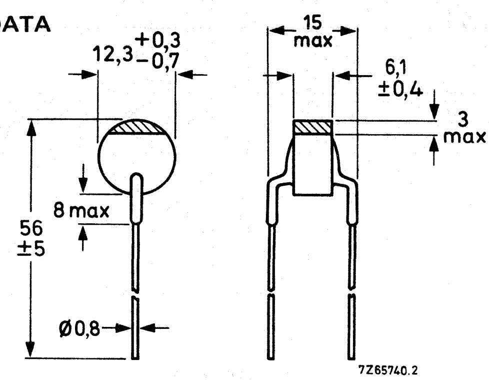


Fig. 1.

Marking	Green colour band on top of the body.
Mass	4,2 g approximately.
Mounting	In any position by soldering. Soldering should be done at least 15 mm from the thermistor body.

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

Resistance	
at +25 °C *	45 to 60 Ω
at +75 °C *	< 160 Ω
at +150 °C, V_{pulse} = 340 V **	> 45 kΩ
Switch temperature	+75 °C approximately
Temperature coefficient	+20%/K approximately
Dissipation factor ▲	20 mW/K approximately
Heat capacity ▲	2,2 J/K approximately
Thermal time constant ▲	110 s approximately
Operating temperature range	
at zero power	–25 to +155 °C
at V_{max}	0 to +60 °C
Maximum RMS voltage, with series resistor of 33 Ω	265 V

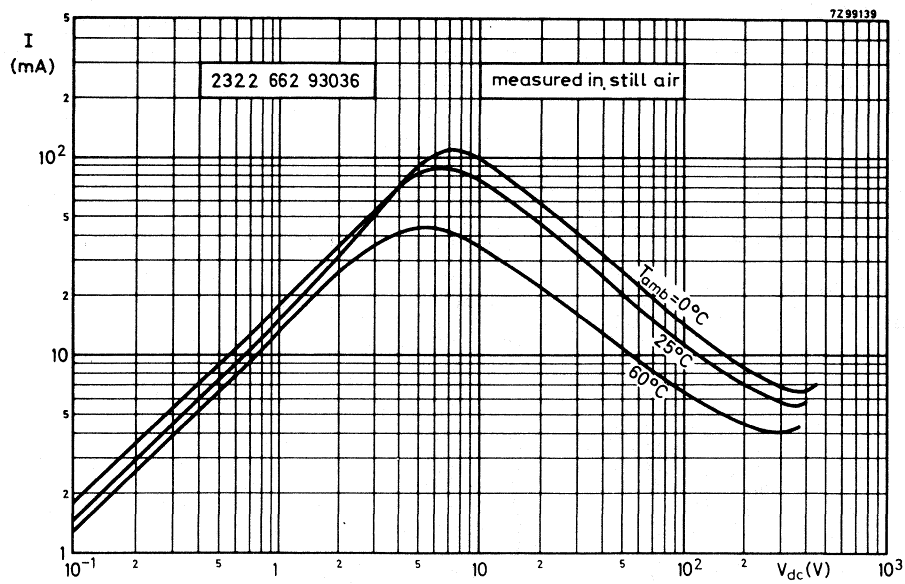


Fig. 2 Typical voltage/current characteristics.

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

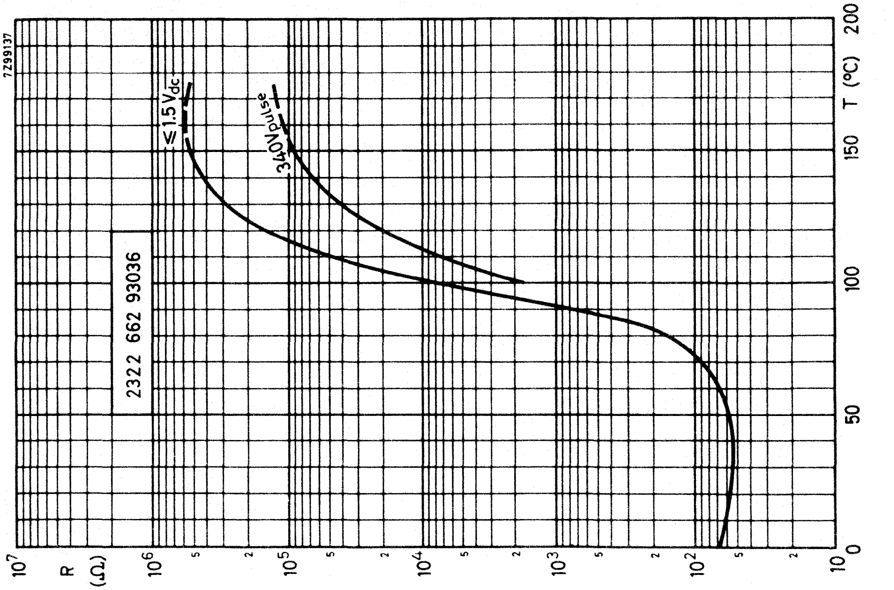


Fig. 4 Typical resistance/temperature characteristics (no internal heating).

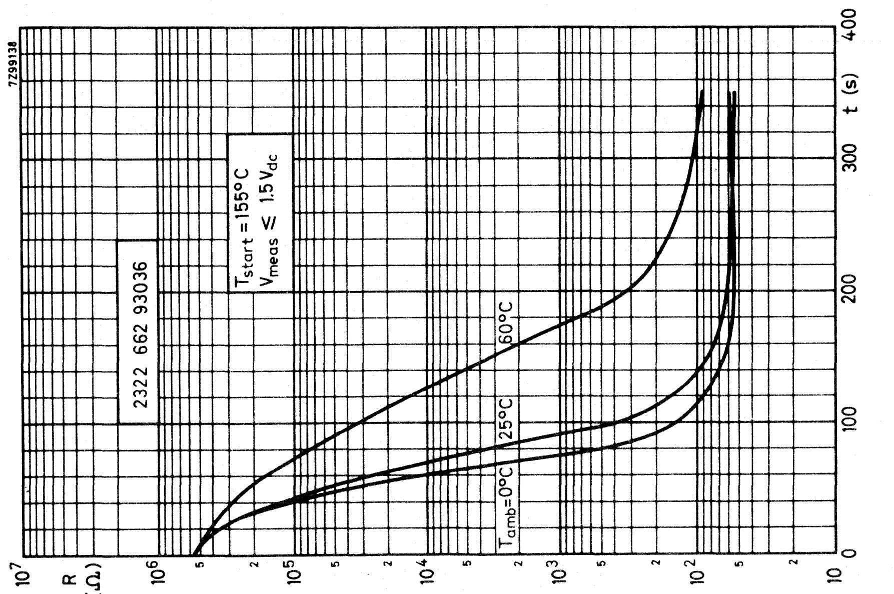


Fig. 3 Typical resistance/time (cooling) characteristics.

PTC THERMISTOR
disc

QUICK REFERENCE DATA

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

APPLICATION

General purpose.

DESCRIPTION

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

MECHANICAL DATA

Outlines

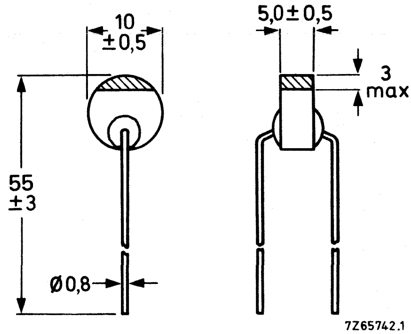


Fig. 1.

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

Mass 2,7 g approx.

Mounting In any position by soldering at min 15 mm from the body.

Robustness of terminations

Tensile strength	20 N
Bending	10 N

Soldering

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

PACKAGING

100 thermistors in a cardboard box.

ELECTRICAL DATA

All values without further indication are approximate values.

Resistance value	
at +25 °C *	100 Ω ± 20%
at +72 °C *	$< 2 \times R_{25}$
at +85 °C *	$> 2 \times R_{25}$
at +155 °C and V_{pulse} = 380 V **	⩾ 40 kΩ
Switch temperature	+75 °C
Temperature coefficient	+35%/K
Maximum rms voltage, with series resistor of 33 Ω	265 V
Dissipation factor ▲	15,3 mW/K
Thermal time constant ▲	80 s
Heat capacity of complete thermistor ▲	1,2 J/K
Operating temperature range	
at zero power	–25 to +155 °C
at maximum voltage	0 to +60 °C

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

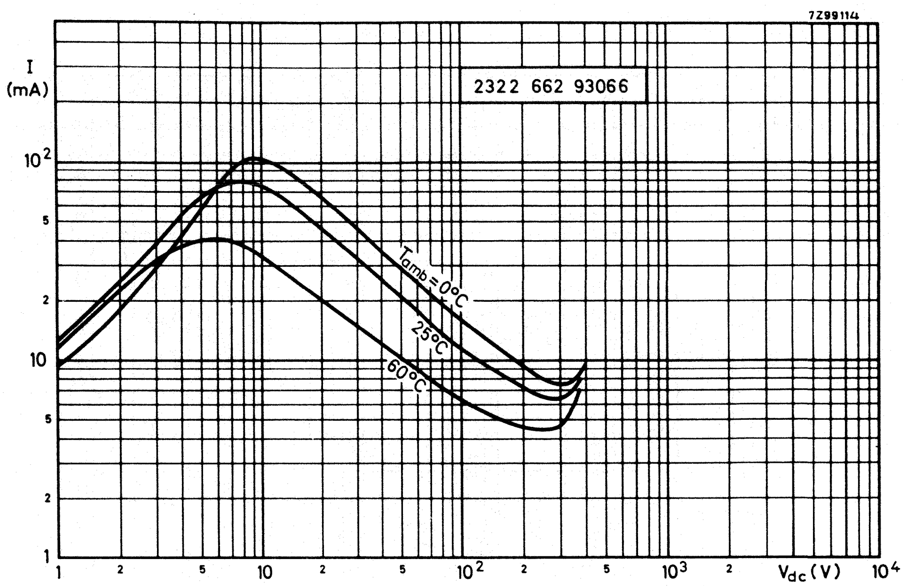


Fig. 3 Typical voltage/current characteristics.

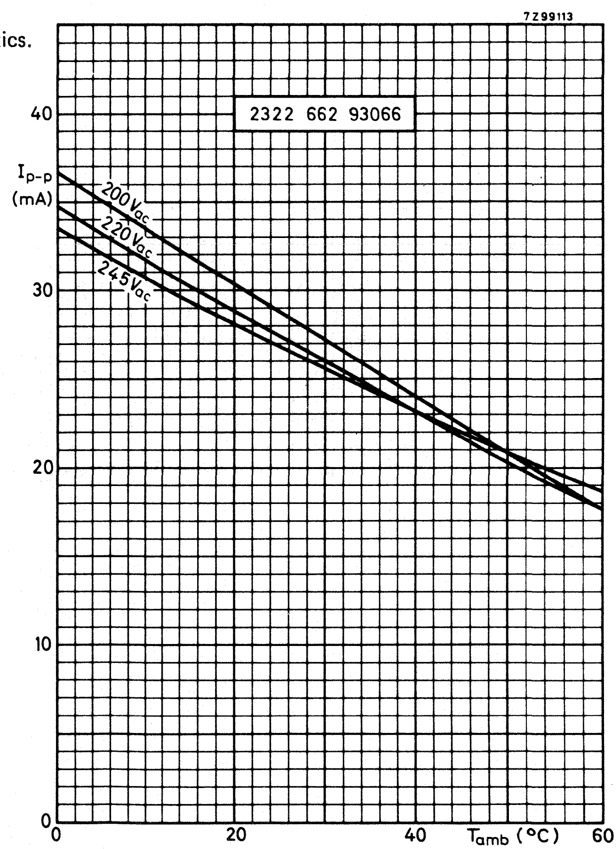


Fig. 4 Typical characteristics of peak to peak current against the ambient temperature at different voltages.

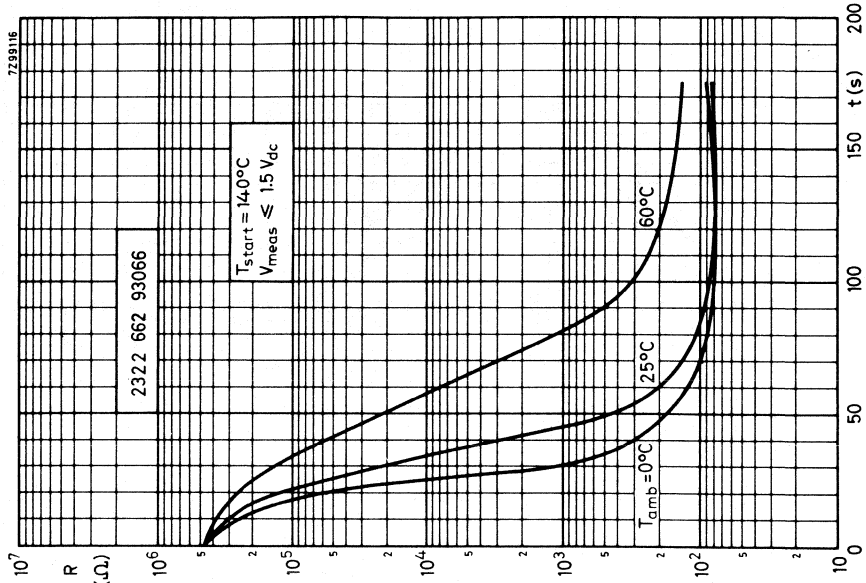


Fig. 6 Typical resistance/time (cooling) characteristics.

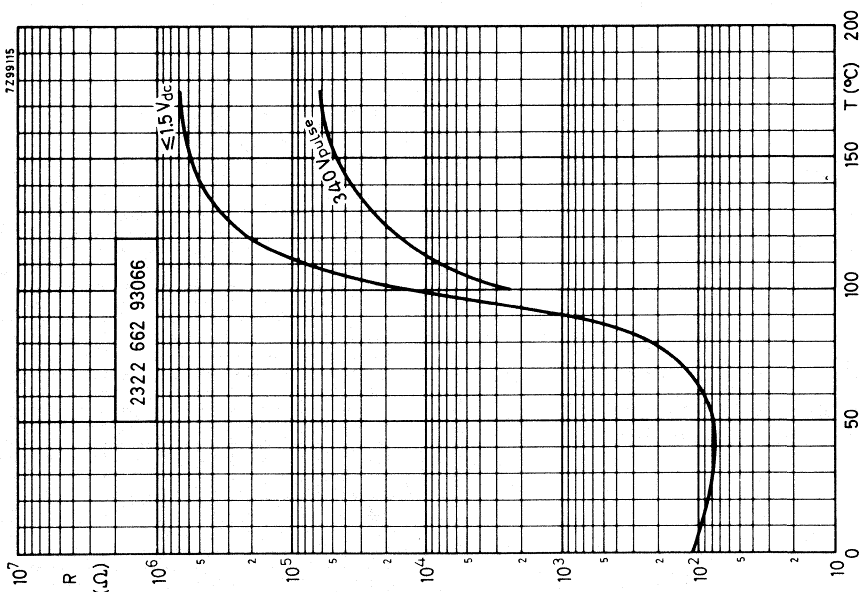


Fig. 5 Typical resistance/temperature characteristics.

PTC THERMISTORS FOR DEGAUSSING

The survey shown in Table 1 details the range of PTC thermistors available for degaussing purposes.

Table 1 Survey of types

catalogue number	type	V_{max} (RMS) V	minimum inrush current A p-p	maximum residual current mA p-p	R_{25} value Ω	coil impedance Ω
2322 662 93702	mono	290	25	45	18	8
2322 662 96176	mono	290	25	45	18	8
2322 662 96009	dual	265	10	4	36	17-25
2322 662 96011	dual	145/265	7.2/13	4	30	17
2322 662 96012	dual	265	11.6	11.6	36	15.5
2322 662 96013	dual	145	20	10	8	6.2
2322 662 96016	dual	265	12	6	25	25
2322 662 96022	dual	265	10	1	38	17-25
2322 662 96024	dual	265	10	4	36	17-25
2322 662 96025	dual	270	10	4	36	25
2322 662 96111	dual	265	13	4	30	17
2322 662 96116	dual	265	12	6	24	25
2322 662 96118	dual	265	10	2	36	17-25
2322 662 96122	dual	145/270	6.6/14.4	10	25	12
2322 662 96123	dual	245	16.2	6	18	14
2322 662 96124	dual	270	20	15	20	10
2322 662 96125	dual	140	16	7	8	9
2322 662 96126	dual	270	20	30	18	13

GENERAL MECHANICAL DATA

Unless otherwise stated, the following information is applicable to the complete range of mono and dual thermistors for degaussing. Please consult the applicable data sheet if this information does not apply.

Marking

The thermistors (with the exception of 2322 662 93702) are marked with the following information:

- the last five numbers of the catalogue number
- manufacturer's code of identification
- date of manufacture (4 figures denoting year and week number)

GENERAL MECHANICAL DATA (continued)

Soldering

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

Impact

Free fall	1 m

Inflammability

The thermistors are non-flammable

PACKING

The thermistors (with the exception of 2322 662 93702) are supplied in cardboard boxes, each box containing 600 items.

MONO THERMISTOR
for degaussing

QUICK REFERENCE DATA

Minimum peak to peak inrush current at 220 V RMS	25 A
Maximum peak to peak current at 220 V RMS	
after 3 s	250 mA
after 1 min	45 mA
Maximum RMS voltage	290 V
Operating temperature range	
at zero power	–25 to 125 °C
at maximum voltage	0 to 55 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

MECHANICAL DATA

Dimensions in mm

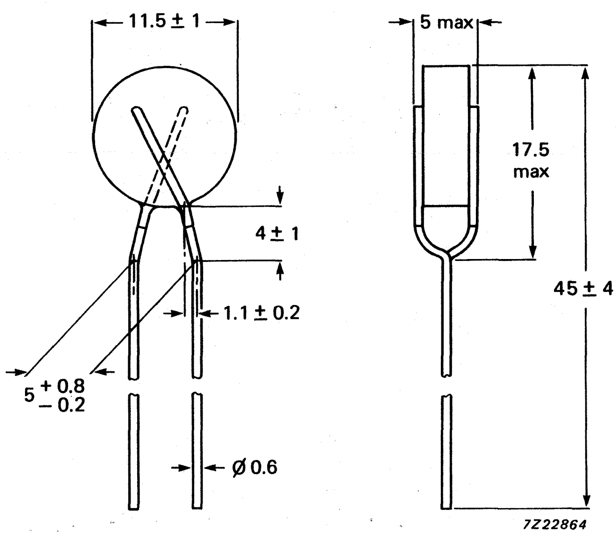


Fig.1 Component outline.

Marking

The thermistors have a grey lacquered coating on the body.

PACKING

The thermistors are supplied in cardboard boxes, each box containing 250 items.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak to peak inrush current at 220 V RMS	25 A
Maximum peak to peak current at 220 V RMS	
after 3 s	250 mA
after 1 min	45 mA
Maximum RMS voltage	290 V
Resistance of the PTC at 25 °C	18 Ω ± 30%
Coil impedance	8 Ω
Switching temperature of the PTC	50 °C approx.
Operating temperature range	
at zero power	–25 to 125 °C
at maximum power	0 to 55 °C

DUAL THERMISTOR
for degaussing

QUICK REFERENCE DATA

Minimum peak to peak inrush current at 200 V RMS	10 A
Maximum peak to peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains
Pins A and C to be connected to the coil

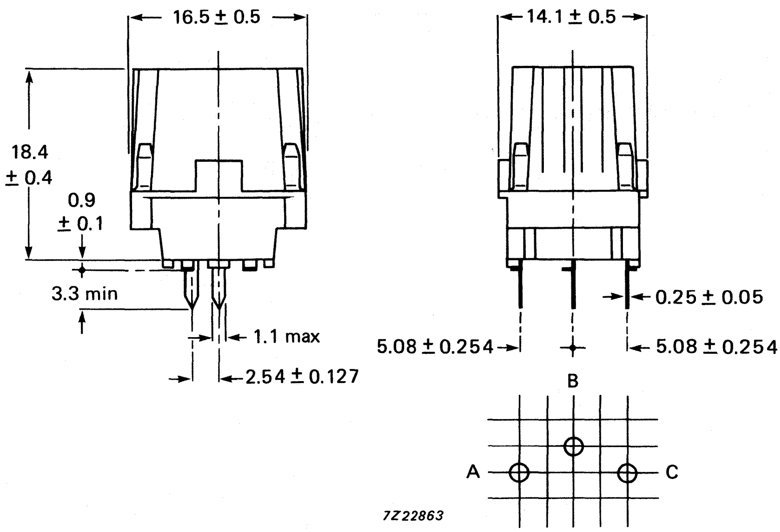
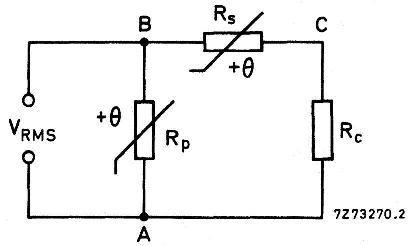


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak to peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	10 A
Maximum peak to peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V RMS
Resistance of the series PTC (R_s) at 25 °C	36 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	2 kΩ approx.
Coil impedance	17 to 25 Ω
Operating temperature range	
at zero power	–25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak to peak inrush current at:	200 V RMS	120 V RMS
	13 A	7.2 A
Maximum peak to peak current at:	200 V RMS	120 V RMS
after 30 s	10 mA	10 mA
after 3 min	4 mA	4 mA
Maximum RMS voltage	265 V	
Operating temperature range		
at zero power	−25 to 125 °C	
at maximum voltage	0 to 60 °C	

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board

Pins A and B to be connected to the mains
Pins A and C to be connected to the coil

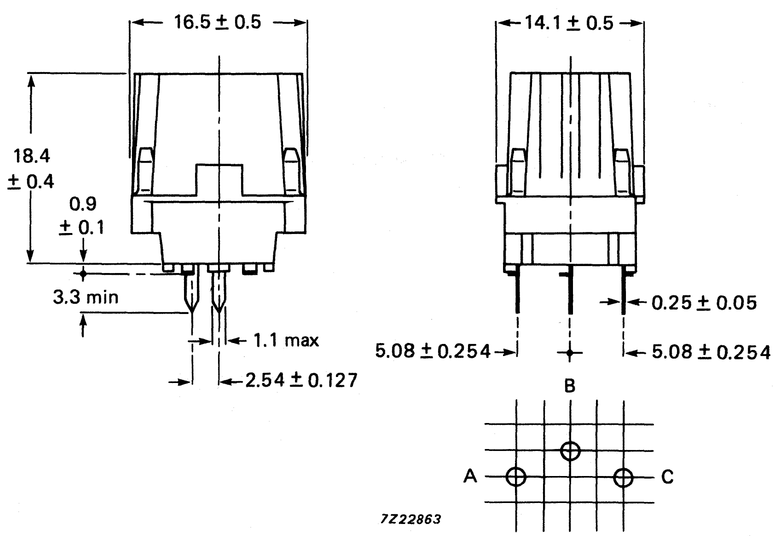
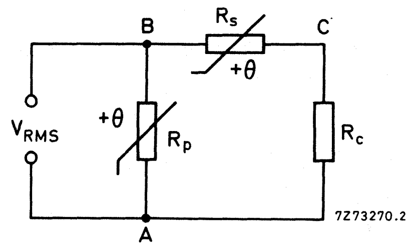


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56	
Minimum peak to peak inrush current at:	200 V RMS	120 V RMS
(measured using the circuit shown in Fig.2)	13 A	7.2 A
Maximum peak to peak current at:	200 V RMS	120 V RMS
(measured using the circuit shown in Fig.2)		
after 30 s	10 mA	10 mA
after 3 min	4 mA	4 mA
Maximum RMS voltage in measuring circuit	265 V	
Resistance of the series PTC (R_s) at 25 °C	30 Ω ± 25%	
Resistance of the parallel PTC (R_p) at 25 °C	1 kΩ approx.	
Coil impedance	17 Ω	
Operating temperature range		
at zero power	–25 to 125 °C	
at maximum power	0 to 60 °C	



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 17 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR
for degaussing

QUICK REFERENCE DATA

Minimum peak to peak inrush current at 200 V RMS	11.6 A
Maximum peak to peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	24 mA
after 4 min	11.6 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive and negative temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board

Pin A to be connected to the load
Pin B to be connected to the mains
Pin C to be connected to the coil

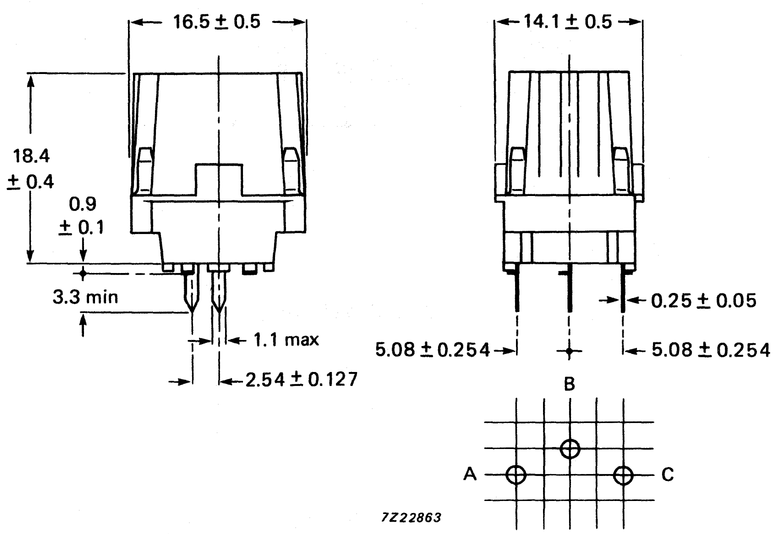
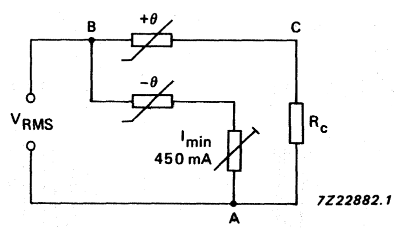


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak to peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	11.6 A
Maximum peak to peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	24 mA
after 4 min	11.6 mA
Resistance of the PTC at 25 °C	36 Ω ± 25%
Resistance of the NTC at 25 °C	130 Ω ± 20%
Coil impedance	15.5 Ω min.
Switching temperature of the PTC	65 °C
Permissible supply voltage range	187 to 265 V RMS
Maximum current through the NTC at	
187 V RMS	1.4 A
265 V RMS	1 A
Minimum current through the NTC to ensure peak current at 200 V RMS	450 mA RMS
Operating temperature range	
at zero power	–25 to 125 °C
at maximum power	0 to 60 °C



T_{amb} = 25 °C
AB = NTC
BC = PTC
R_c replaces the degaussing coil (Z = 18.9 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR
for degaussing

QUICK REFERENCE DATA

Minimum peak to peak inrush current at 100 V RMS	20 A
Maximum peak to peak current at 100 V RMS	
after 5 s	280 mA
after 30 s	20 mA
after 3 min	10 mA
Maximum RMS voltage	145 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board

Pins A and B to be connected to the mains
Pins A and C to be connected to the coil

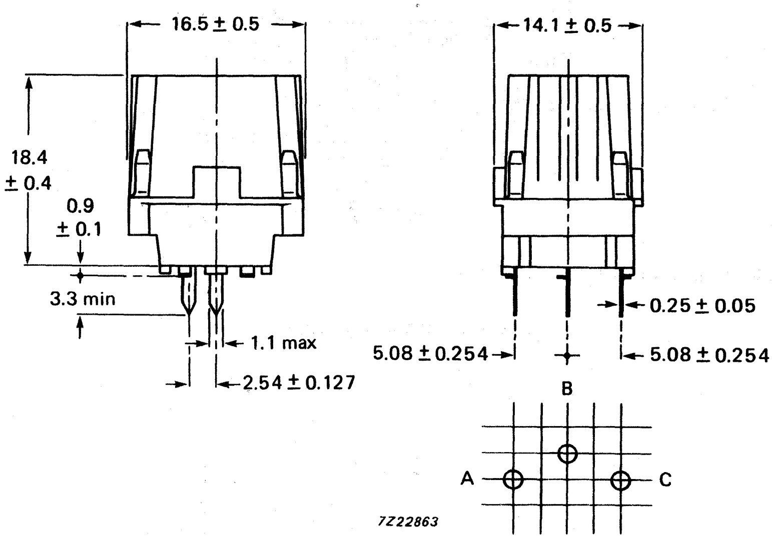
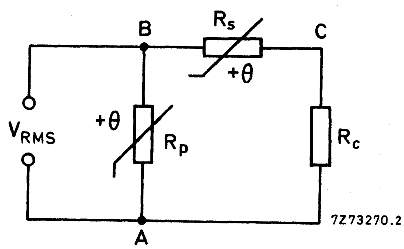


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak to peak inrush current at 100 V RMS (measured using the circuit shown in Fig.2)	20 A
Maximum peak to peak current at 100 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	280 mA
after 30 s	20 mA
after 3 min	10 mA
Maximum RMS voltage in measuring circuit (Fig.2)	145 V
Resistance of the series PTC (R_s) at 25 °C	8 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	1 kΩ approx.
Coil impedance	6.2 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 6.2 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 200 V RMS	12 A
Maximum peak-to-peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

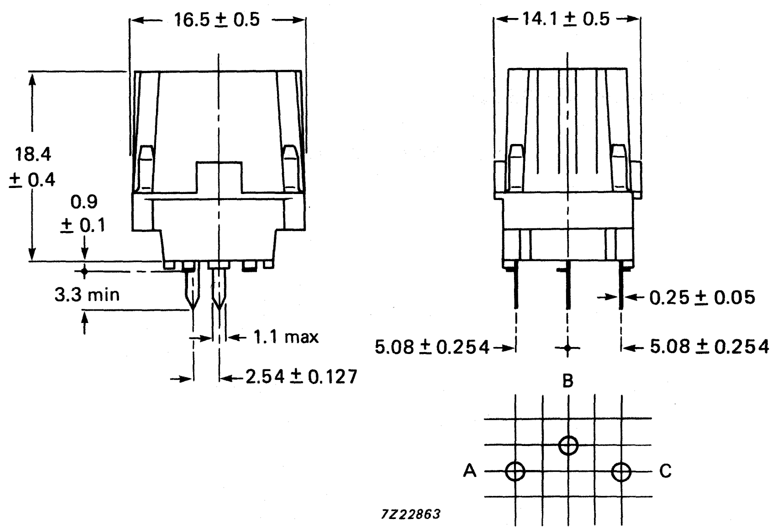
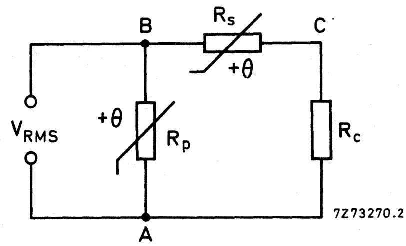


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	12 A
Maximum peak-to-peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V
Resistance of the series PTC (R_s) at 25 °C	25 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	750 Ω to 3 kΩ
Coil impedance	25 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 200 V RMS	10 A
Maximum peak-to-peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	1 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

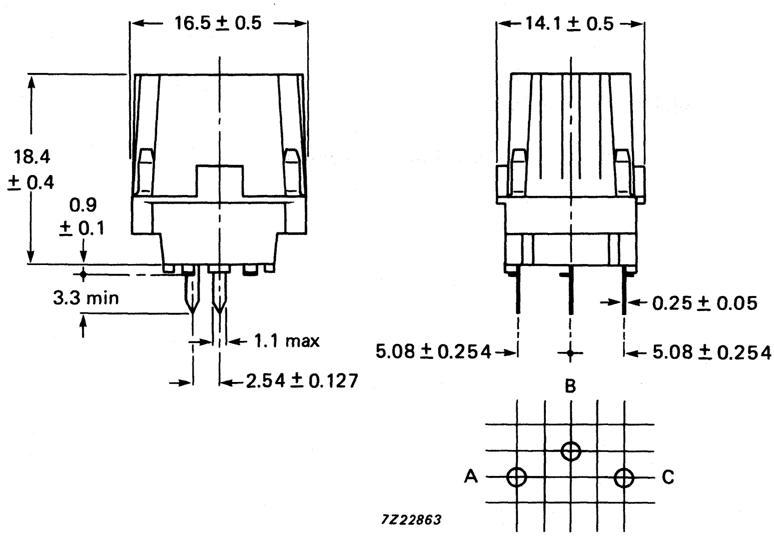
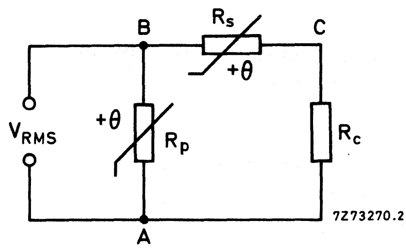


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	10 A
Maximum peak-to-peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	1 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V
Resistance of the series PTC (R_s) at 25 °C	38 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	2 kΩ approx.
Coil impedance	17 to 25 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 200 V RMS	10 A
Maximum peak-to-peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

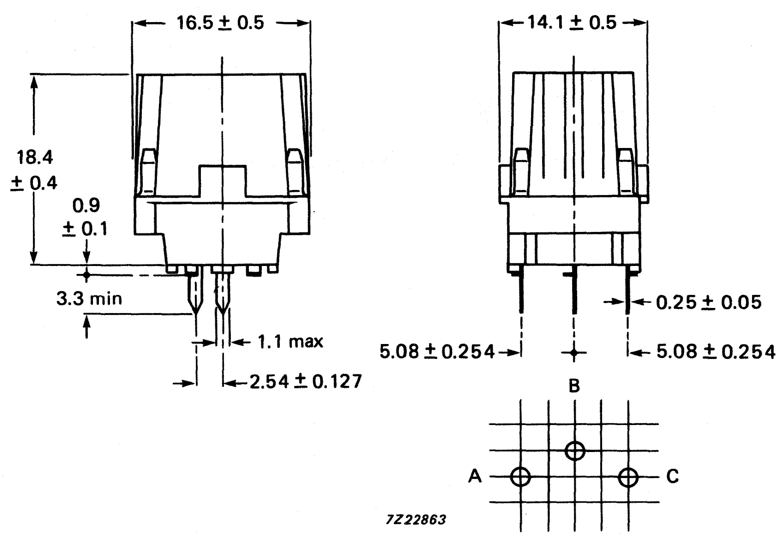
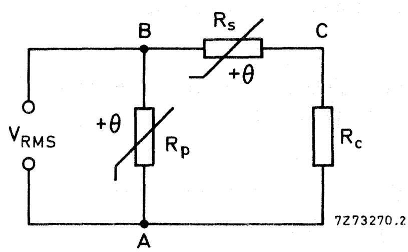


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	10 A
Maximum peak-to-peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	4 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V
Resistance of the series PTC (R_s) at 25 °C	36 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	2 kΩ approx.
Coil impedance	17 to 25 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR
for degaussing

QUICK REFERENCE DATA

Current measured through the coil at 220 V RMS	
Minimum peak-to-peak inrush current	10 A
Maximum peak-to-peak current	
after 3 s	300 mA
after 3 min	4 mA
Maximum RMS voltage	270 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

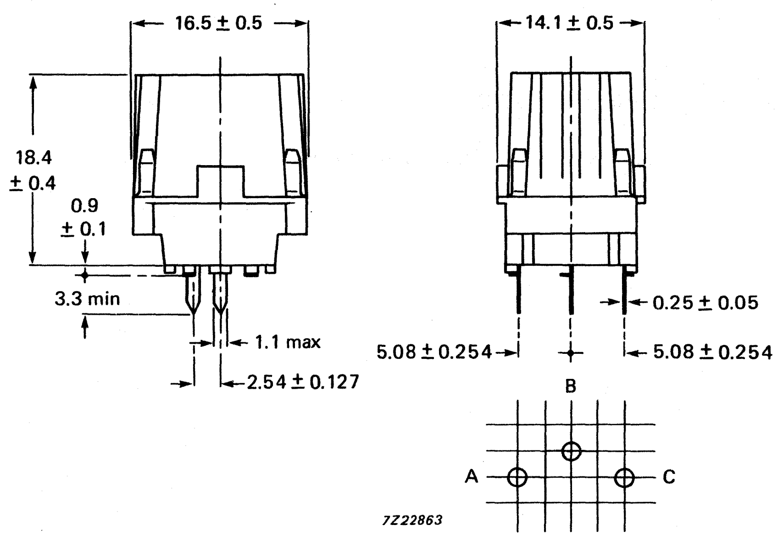
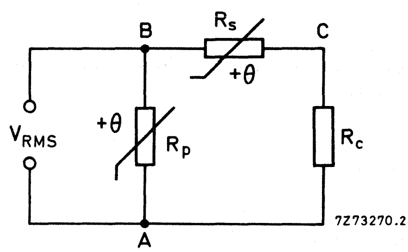


Fig.1 Component outline and mounting grid.

MECHANICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 220 V RMS (measured using the circuit shown in Fig.2)	10 A
Maximum peak-to-peak current at 220 V RMS (measured using the circuit shown in Fig.2)	
after 3 s	300 mA
after 3 min	4 mA
Maximum RMS voltage in measuring circuit (Fig.2)	270 V
Resistance of the series PTC (R_s) at 25 °C	36 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	1 kΩ approx.
Coil impedance	25 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at	200 V RMS	120 V RMS
	13 A	7.2 A
Maximum peak-to-peak current at	200 V RMS	120 V RMS
after 30 s	10 mA	10 mA
after 3 min	4 mA	4 mA
Maximum RMS voltage	265 V	
Operating temperature range		
at zero power	−25 to 125 °C	
at maximum voltage	0 to 60 °C	

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

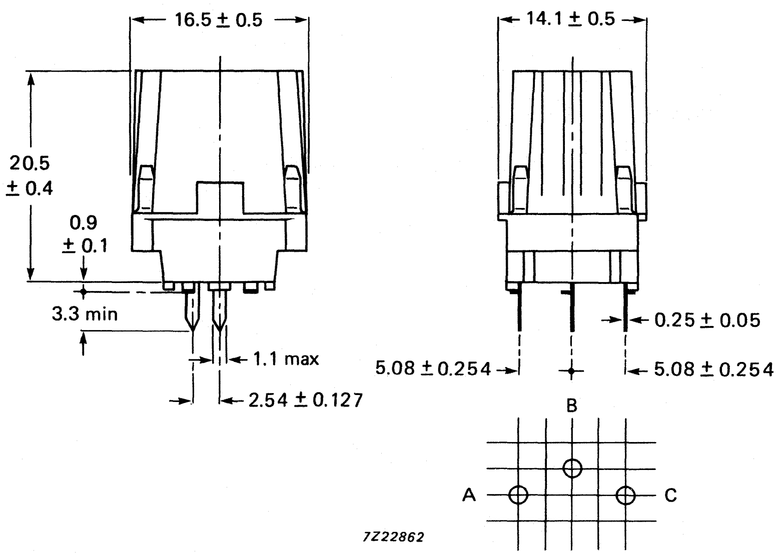
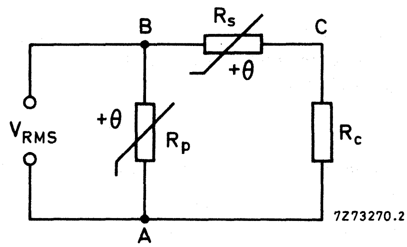


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56	
Minimum peak-to-peak inrush current at (measured using the circuit shown in Fig.2)	200 V RMS 13 A	120 V RMS 7.2 A
Maximum peak-to-peak current at (measured using the circuit shown in Fig.2)	200 V RMS	120 V RMS
after 30 s	10 mA	10 mA
after 3 min	4 mA	4 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V	
Resistance of the series PTC (R_s) at 25 °C	30 Ω ± 25 °C	
Resistance of the parallel PTC (R_p) at 25 °C	1 kΩ approx.	
Coil impedance	17 Ω	
Operating temperature range		
at zero power	−25 to 125 °C	
at maximum power	0 to 60 °C	



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 17 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 200 V RMS	12 A
Maximum peak-to-peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

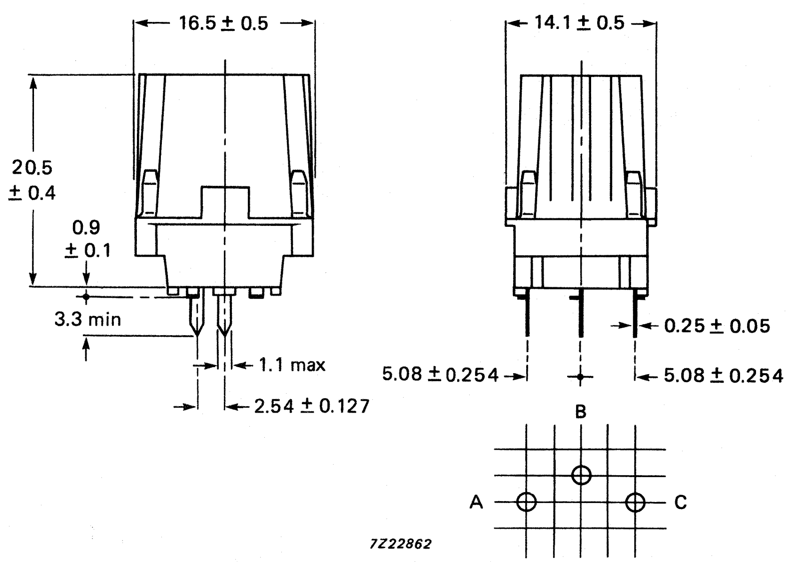
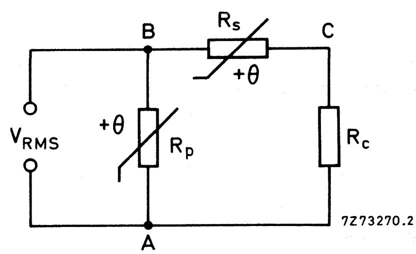


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	12 A
Maximum peak-to-peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V
Resistance of the series PTC (R_s) at 25 °C	24 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	750 Ω to 3 kΩ
Coil impedance	25 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 200 V RMS	10 A
Maximum peak-to-peak current at 200 V RMS	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	2 mA
Maximum RMS voltage	265 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

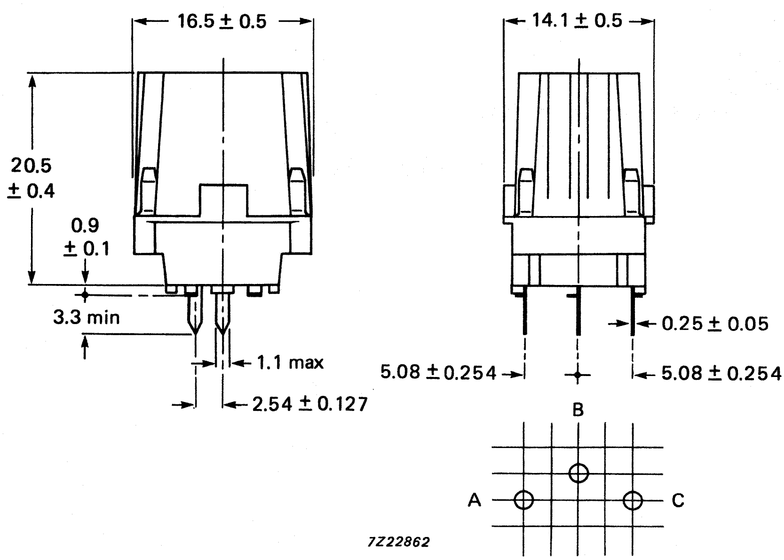
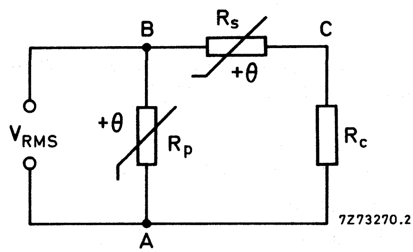


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 200 V RMS (measured using the circuit shown in Fig.2)	10 A
Maximum peak-to-peak current at 200 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	140 mA
after 30 s	10 mA
after 3 min	2 mA
Maximum RMS voltage in measuring circuit (Fig.2)	265 V
Resistance of the series PTC (R_s) at 25 °C	36 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	3 kΩ approx.
Coil impedance	17 to 25 Ω
Operating temperature range	
at zero power	–25 to 125 °C
at maximum power	0 to 60 °C



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

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at	240 V RMS	110 V RMS
	14.4 A	6.6 A
Maximum peak-to-peak current at	240 V RMS	110 V RMS
after 3 s	150 mA	150 mA
after 1 min	10 mA	10 mA
Maximum RMS voltage	270 V	
Operating temperature range		
at zero power	−25 to 125 °C	
at maximum voltage	−10 to 85 °C	

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

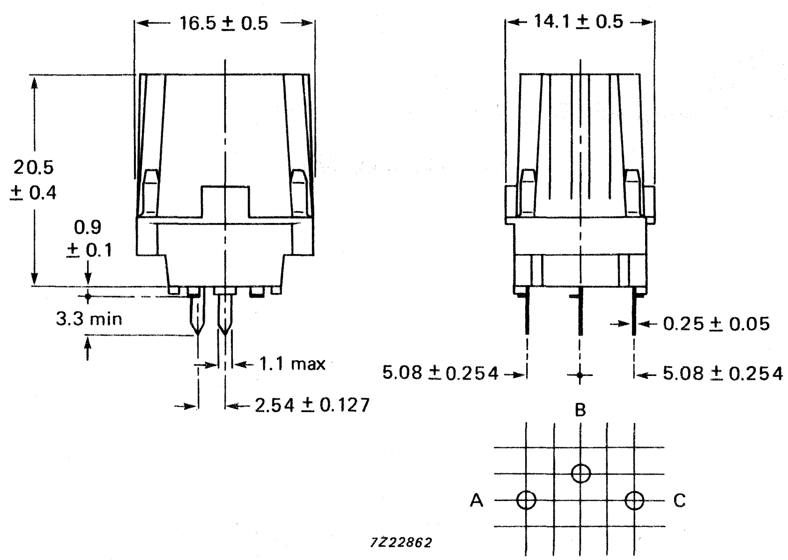
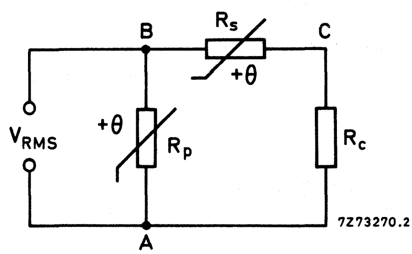


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56	
Minimum peak-to-peak inrush current at	240 V RMS	110 V RMS
(measured using the circuit shown in Fig.2)	14.4 A	6.6 A
Maximum peak-to-peak current at	240 V RMS	110 V RMS
(measured using the circuit shown in Fig.2)		
after 3 s	150 mA	150 mA
after 1 min	10 mA	10 mA
Maximum RMS voltage in measuring circuit (Fig.2)	270 V	
Resistance of the series PTC (R_s) at 25 °C	25 Ω ± 25%	
Resistance of the parallel PTC (R_p) at 25 °C	100 Ω min.	
Coil impedance	12 Ω	
Operating temperature range		
at zero power	−25 to 125 °C	
at maximum power	−10 to 85 °C	



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 12 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 190 V RMS	16.2 A
Maximum peak-to-peak current at 190 V RMS	
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage	245 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive and negative temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

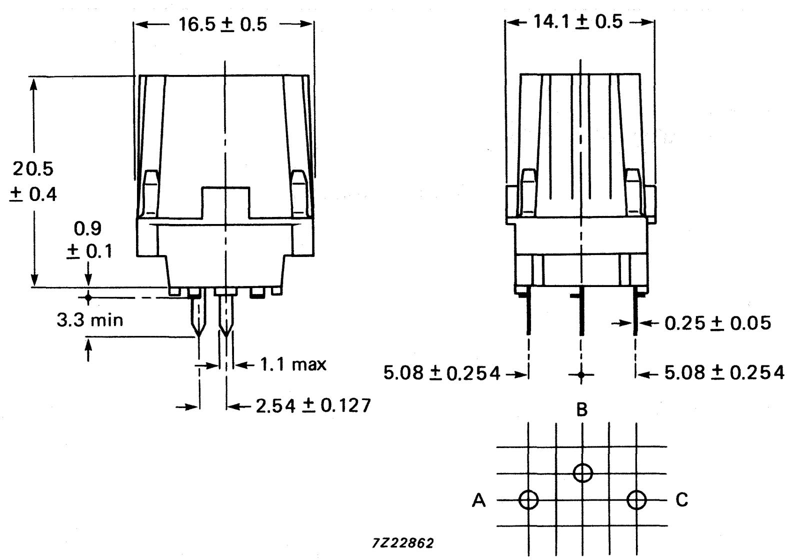
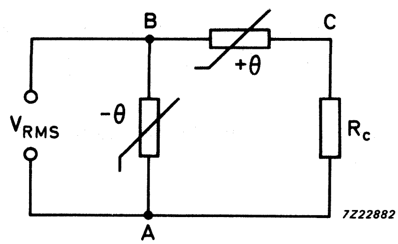


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 190 V RMS (measured using the circuit shown in Fig.2)	16.2 A
Maximum peak-to-peak current at 190 V RMS (measured using the circuit shown in Fig.2)	
after 30 s	12 mA
after 3 min	6 mA
Maximum RMS voltage in measuring circuit (Fig.2)	245 V
Resistance of the series PTC (R_s) at 25 °C	18 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	2 kΩ approx.
Coil impedance	14 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 14 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 220 V RMS	20 A
Maximum peak-to-peak current at 220 V RMS	
after 5 s	300 mA
after 3 min	15 mA
Maximum RMS voltage	270 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins a. e suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

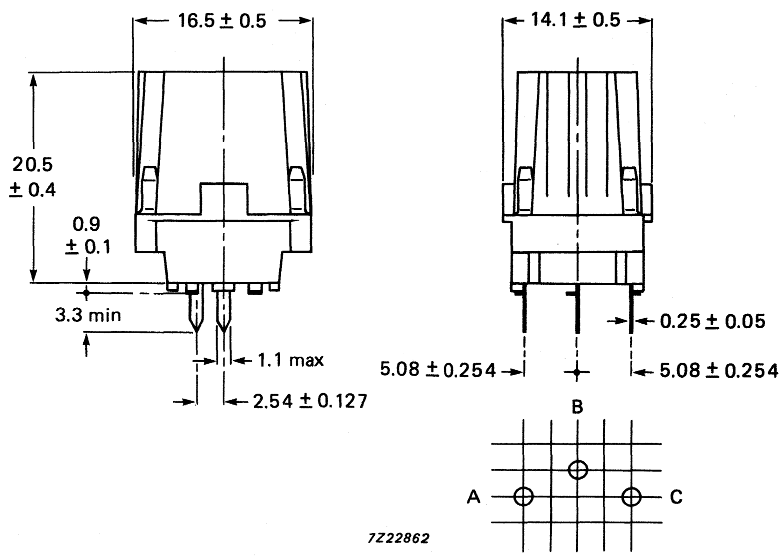
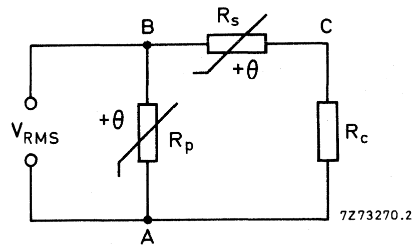


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 220 V RMS (measured using the circuit shown in Fig.2)	20 A
Maximum peak-to-peak current at 220 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	300 mA
after 3 min	15 mA
Maximum RMS voltage in measuring circuit (Fig.2)	270 V
Resistance of the series PTC (R_s) at 25 °C	20 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	750 Ω to 3 kΩ
Coil impedance	10 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 10 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 120 VRMS	16 A
Maximum peak-to-peak current at 120 V RMS	
after 5 s	300 mA
after 3 min	7 mA
Maximum RMS voltage	140 V
Operating temperature range	
at zero power	−25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION

These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

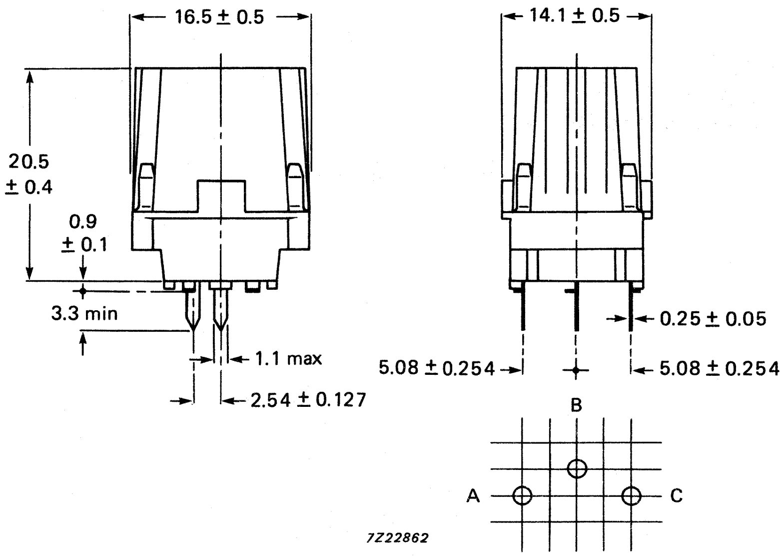
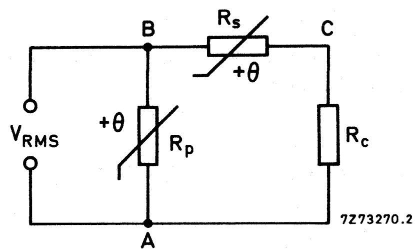


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 120 V RMS (measured using the circuit shown in Fig.2)	16 A
Maximum peak-to-peak current at 120 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	300 mA
after 3 min	7 mA
Maximum RMS voltage in measuring circuit (Fig.2)	140 V
Resistance of the series PTC (R_s) at 25 °C	8 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	750 Ω to 3 kΩ
Coil impedance	9 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 9 Ω)

Fig.2 Measuring circuit.

DUAL THERMISTOR
for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 220 V RMS	20 A
Maximum peak-to-peak current at 220 V RMS	
after 5 s	150 mA
after 30 s	30 mA
Maximum RMS voltage	270 V
Operating temperature range	
at zero power	–25 to 125 °C
at maximum voltage	0 to 60 °C

APPLICATION
These directly heated positive temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION
The thermistor consists of two discs encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA
Dimensions in mm

Mounting grid viewed from solder side of printed wiring board.

Pins A and B to be connected to the mains.

Pins A and C to be connected to the coil.

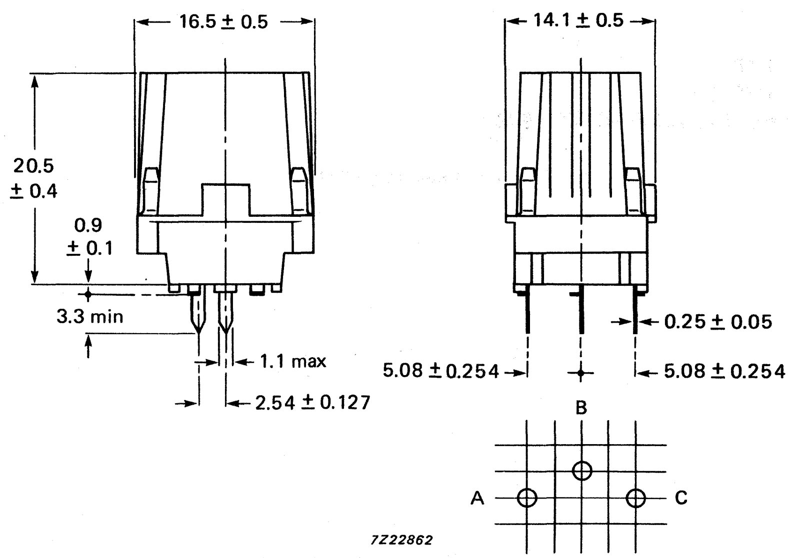
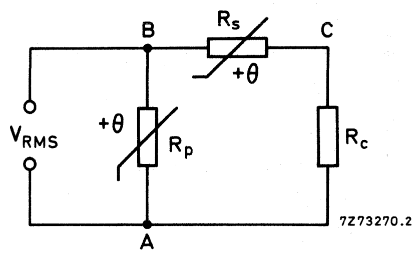


Fig.1 Component outline and mounting grid.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 220 V RMS (measured using the circuit shown in Fig.2)	20 A
Maximum peak-to-peak current at 220 V RMS (measured using the circuit shown in Fig.2)	
after 5 s	150 mA
after 30 s	30 mA
Maximum RMS voltage in measuring circuit (Fig.2)	270 V
Resistance of the series PTC (R_s) at 25 °C	18 Ω ± 25%
Resistance of the parallel PTC (R_p) at 25 °C	750 Ω to 3 kΩ
Coil impedance	13 Ω
Operating temperature range	
at zero power	−25 to 125 °C
at maximum power	0 to 60 °C



R_s = series PTC
R_p = parallel PTC
R_c replaces the degaussing coil (Z = 13 Ω)

Fig.2 Measuring circuit.

MONO THERMISTOR

for degaussing

QUICK REFERENCE DATA

Minimum peak-to-peak inrush current at 220 V RMS	25 A
Maximum peak-to-peak current at 220 V RMS	
after 3 s	250 mA
after 3 min	45 mA
Maximum RMS voltage	290 V
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum voltage	0 to + 55 °C

APPLICATION

These directly heated positive mono temperature coefficient thermistors are mainly used in degaussing circuits of colour television receivers and colour monitors.

DESCRIPTION

The thermistor consists of a disc encapsulated within a plastic housing. The pins are suitable for soldering directly onto a printed wiring board.

MECHANICAL DATA

Dimensions in mm

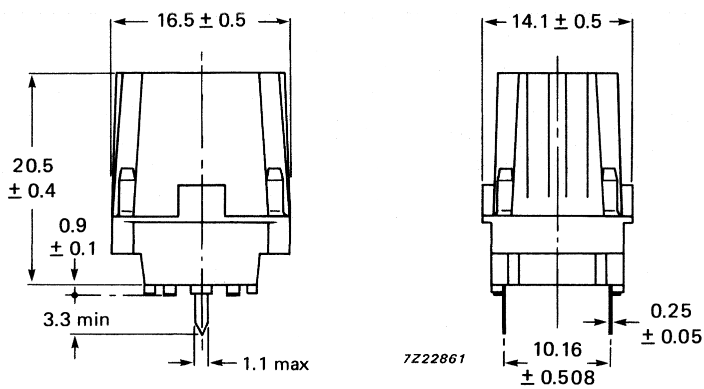


Fig.1 Component outline.

ELECTRICAL DATA

Climatic category	25/125/56
Minimum peak-to-peak inrush current at 220 V RMS	25 A
Maximum peak-to-peak current at 220 V RMS	
after 3 s	250 mA
after 3 min	45 mA
Maximum RMS voltage	290 V
Resistance of the PTC at 25 °C	18 Ω ± 30%
Coil impedance	8 Ω
Operating temperature range	
at zero power	−25 to + 125 °C
at maximum power	0 to + 55 °C

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 approximately ←
Temperature coefficient	+10%/K
Maximum DC voltage	16 V
Dissipation factor	27 mW/K
Operating temperature range	
at zero power	−25 to +155 °C
at V_{max}	−25 to +55 °C

APPLICATION

Overload protection, e.g. of relay coils, small motors, etc.

DESCRIPTION

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

MECHANICAL DATA

Outlines

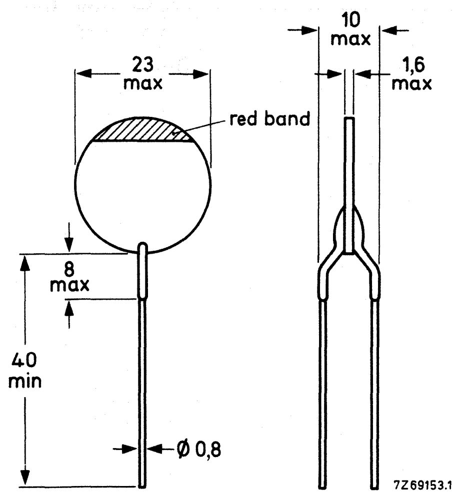


Fig. 1.

PACKAGING

100 thermistors in a cardboard box.

Marking	The thermistors are marked with a red band.
Mass	2,3 g 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, all measurements are in accordance with IEC Publication 738-1 (1982).

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

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

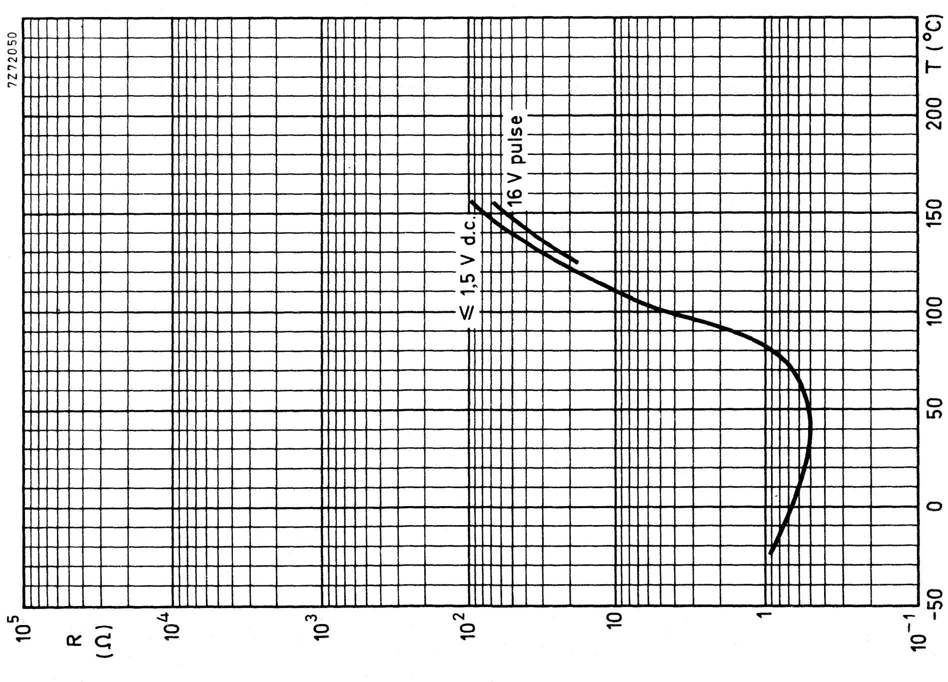


Fig. 2 Typical resistance/temperature characteristics.

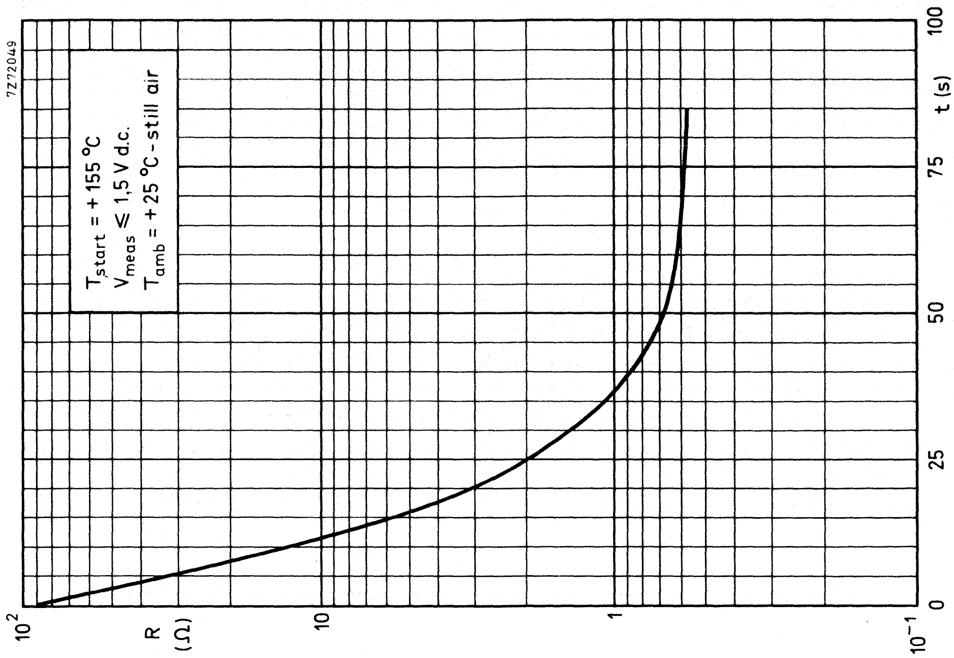


Fig. 3 Typical resistance/time (cooling) characteristic.

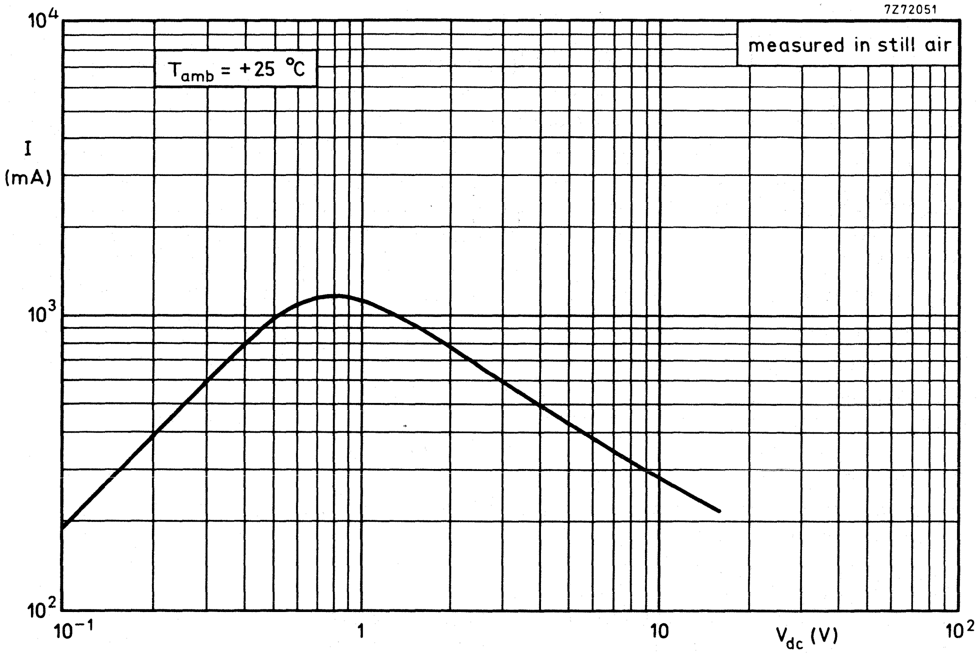


Fig. 4 Typical voltage/current characteristic.

PTC THERMISTORS

for overload protection

QUICK REFERENCE DATA

Resistance at 25 °C	1,6 to 90 Ω
Switch temperature	120 °C approximately
Maximum DC voltage	56 V
Trip current at 10 °C	112 to 1360 mA
Operating temperature range at V_{max}	0 to + 55 °C

APPLICATION

Overload protection, for use in electric and electronic equipment such as electric motors, transformers and semiconductor circuits.

DESCRIPTION

These thermistors have a positive temperature coefficient. They consist of a disc with two tinned brass wires, see Fig. 1a. Leadless types having metallized sides for soldering by the user are also available, see Fig. 1b.

MECHANICAL DATA

Outlines

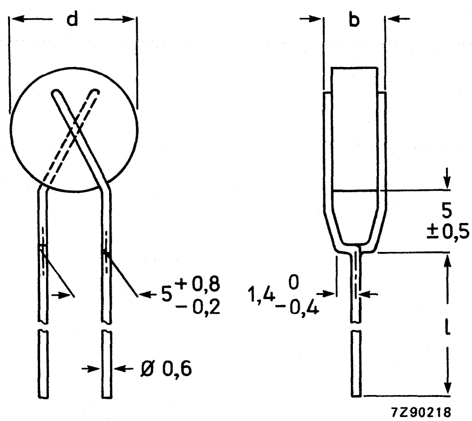


Fig. 1a.

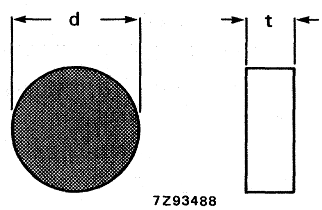


Fig. 1b.

For dimensions b, d, l and t see Table 1.

Marking	None
Mass (types with leads only)	See Table 1
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

When soldering leadless types it is recommended to use a flux containing colofonium and aethyl alcohol only and to pre-heat the discs to approx. 100 °C in order to avoid thermal shocks which might damage the thermistors.

Impact	200 mm free fall
Inflammability	non-flammable

Packaging (for types with leads)

Cardboard boxes containing following items for:

→ 2322 6601 . . . 1:	500	2322 6621 . . . 1:	100
→ 2322 6611 . . . 1:	250	2322 6631 . . . 1:	100
→ 2322 6621 1811.	200	2322 6631 . . . 1:	100

ELECTRICAL DATA

Unless otherwise specified measured according to IEC publication 738-1 (1982).

Maximum current for not tripping at 55 °C (measuring time 5 minutes)	I_{nt}	See Table 1
Minimum current for tripping after 5 minutes at 10 °C	$I_t = 2 \times I_{nt}$	See Table 1
Resistance at + 25 °C	R_{25}	See Table 1
Switch temperature	T_s	≈ 120 °C
Maximum admissible current at 0 °C	I_{max}	See Table 1
Maximum residual current at 56 V (DC) at 10 °C	$I_{res\ max}$	See Table 1
Maximum DC voltage with a series resistor		56 V
Series resistor	R_s	See Table 1
Maximum d.c. voltage without series resistor		18 V
Dissipation factor at T_s	D	See Table 1
Heat capacity	H	See Table 1
Operating temperature range		
at zero power		−25 to + 125 °C
at maximum voltage		0 to + 55 °C

Table 1

catalogue number (see Notes 1 and 2)	I_{nt} at 55 °C mA	I_t at 10 °C mA	R_{25} approx. Ω	I_{max} at 0 °C mA	$I_{res\,max}$ at 10 °C mA	R_s ± 5% Ω	D approx. mW/K	H approx. J/K	d mm	b max. mm	l ± 3 mm	t max. mm	mass approx. (types with leads only) g
2322 660 .5691	56	112	90	460	30	56	6	0,08	4,5	4	20	1,8	0,35
660 .6891	68	136	60	600	30	51	6	0,08	4,5	4	20	1,8	0,35
660 .8291	82	164	42	750	30	43	6	0,08	4,5	4	20	1,8	0,35
661 .1011	100	200	32	950	35	36	7	0,15	6,5	4	20	1,8	0,47
661 .1211	120	240	22	1300	35	27	7	0,15	6,5	4	20	1,8	0,47
661 .1511	150	300	18	1600	40	22	7,5	0,16	8,0	4	20	1,8	0,65
662 .1811	180	360	12,5	2200	45	16	8	0,42	10,0	4,5	20	2,2	1,05
662 .2211	220	440	9	2900	50	13	9	0,55	12,0	4,5	20	2,2	1,43
662 .2711	270	540	6,5	4000	50	10	9	0,55	12,0	4,5	20	2,2	1,43
663 .3311	330	660	4,3	6300	60	5,6	10	0,83	13,0	5	20	2,9	2,15
663 .3911	390	780	3,8	7300	70	5,1	12	1,24	16,0	5	20	2,9	2,90
663 .4711	470	940	2,6	12000	70	2,7	12	1,24	16,0	5	20	2,9	2,90
664 .5611	560	1120	2,2	14000	100	2,4	16	2,34	20,0	6	16	3,6	5,30
664 .6811	680	1360	1,6	18000	100	2,0	16	2,34	20,0	6	16	3,6	5,30

Notes to Table 1

1. For leadless types, replace the dot in the catalogue number by 0; for types with leads, replace it by 1.
2. For taped devices up to 12 mm in diameter, replace the dot by 3.

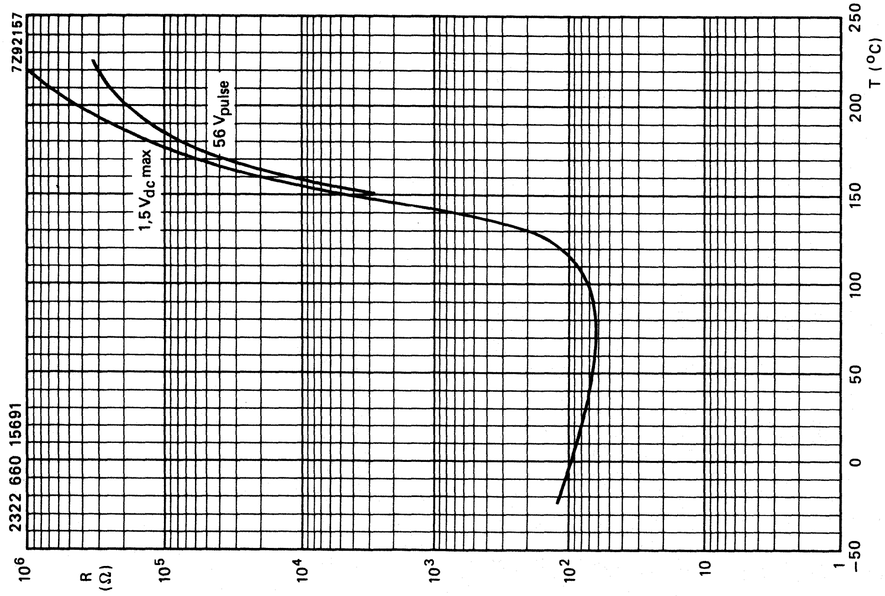


Fig. 2.

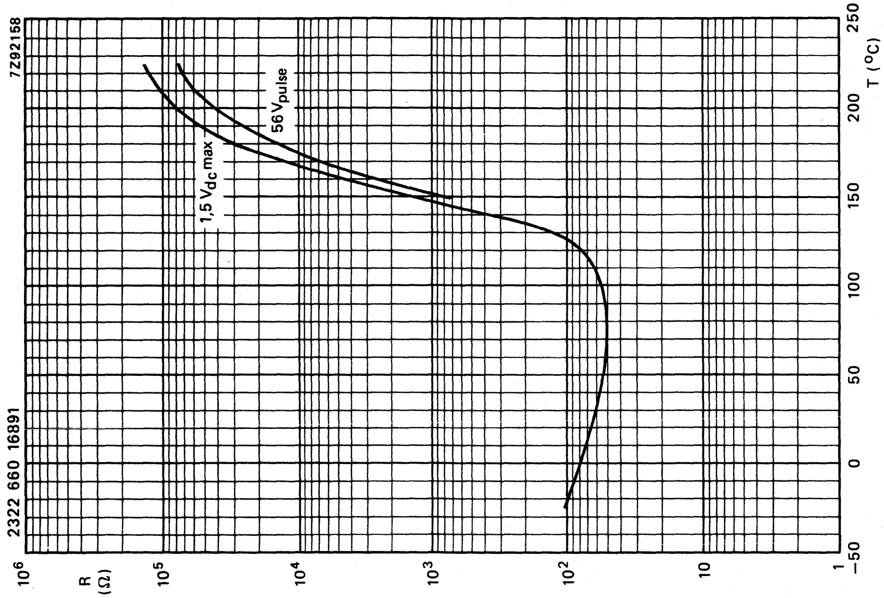


Fig. 3.

Typical resistance/temperature characteristics.

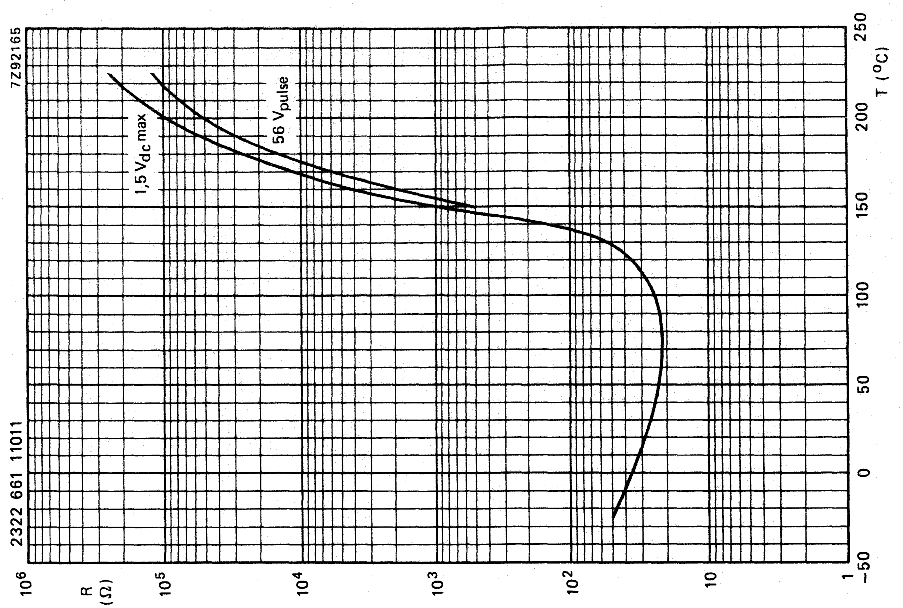


Fig. 5.

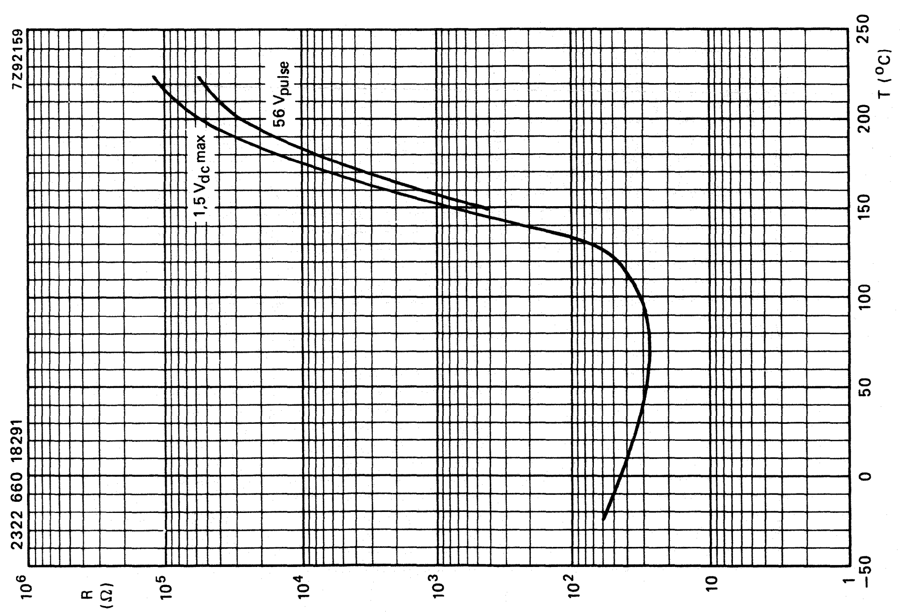


Fig. 4.

Typical resistance/temperature characteristics.

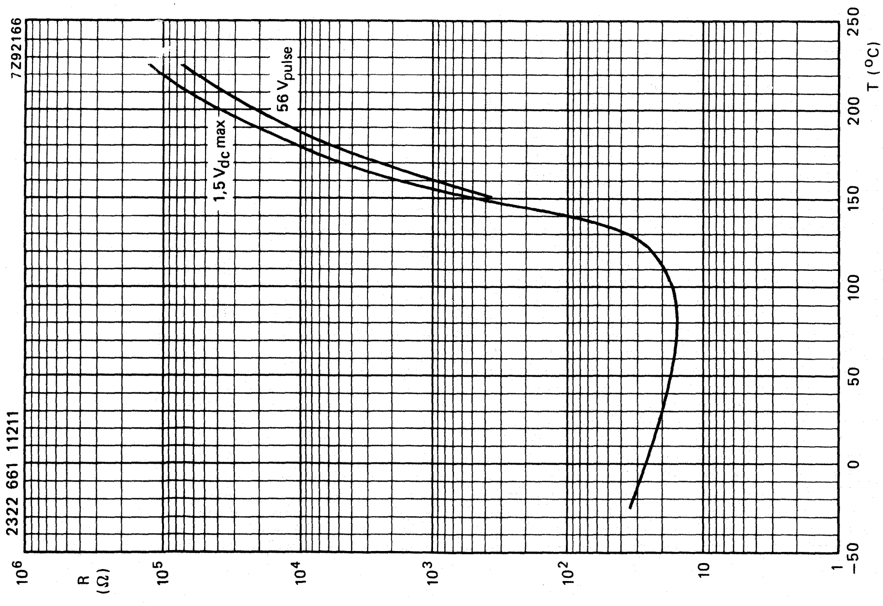


Fig. 6.

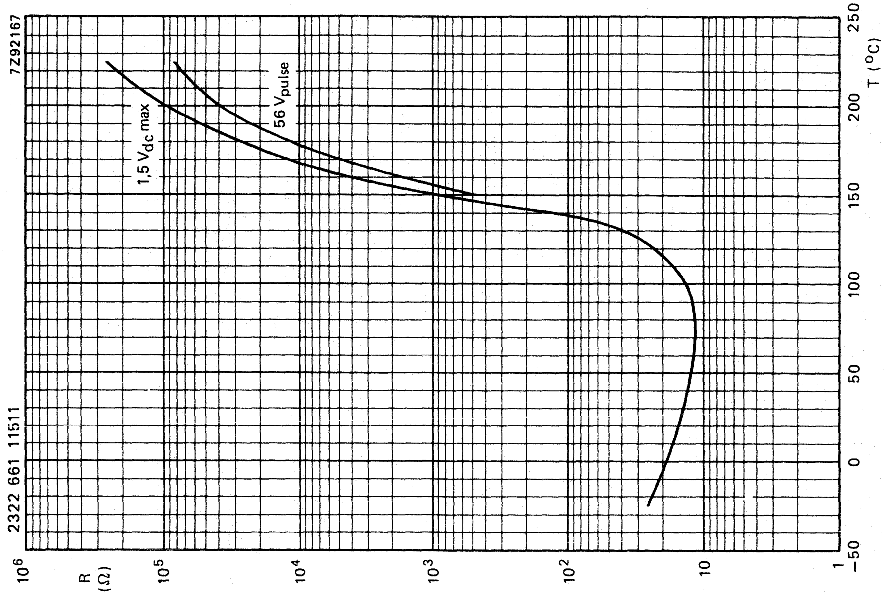


Fig. 7.

Typical resistance/temperature characteristics.

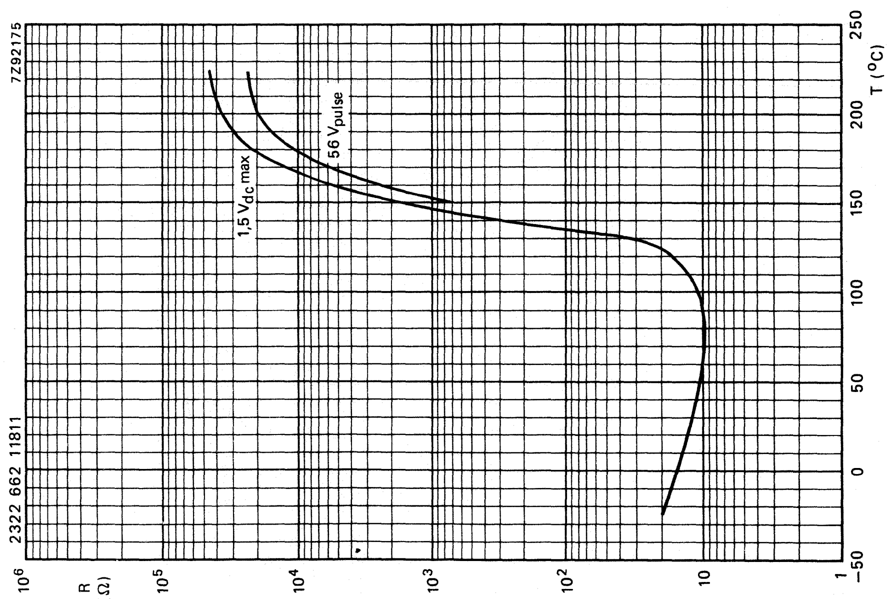


Fig. 8.

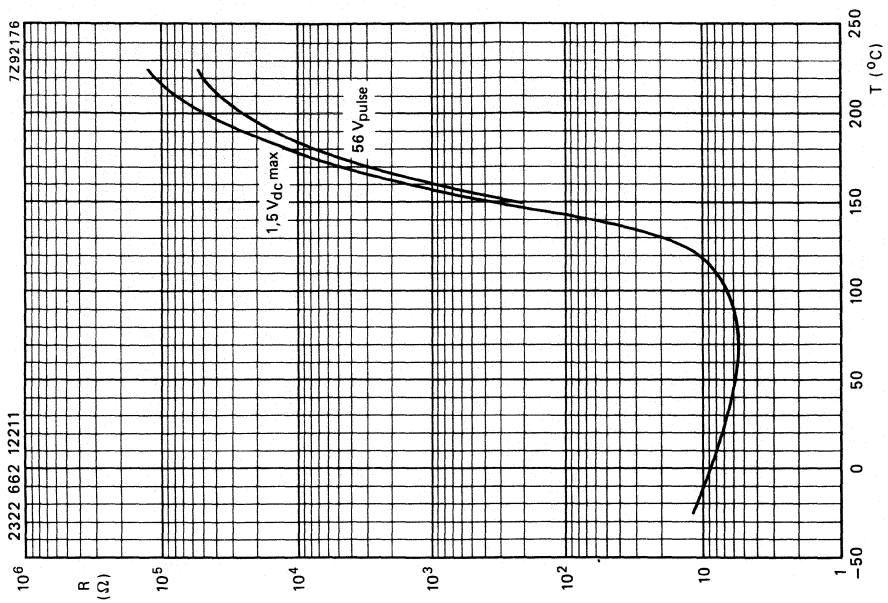


Fig. 9.

Typical resistance/temperature characteristics.

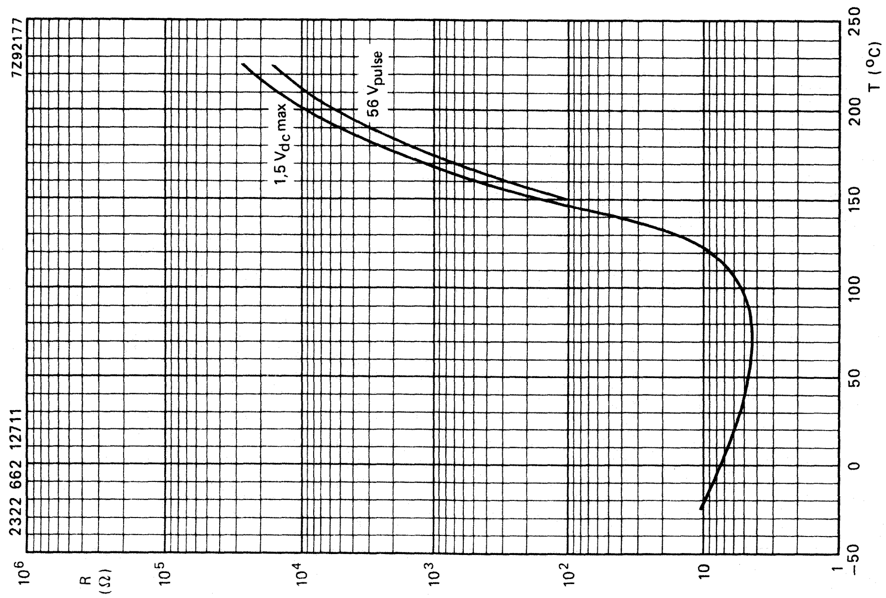


Fig. 10.

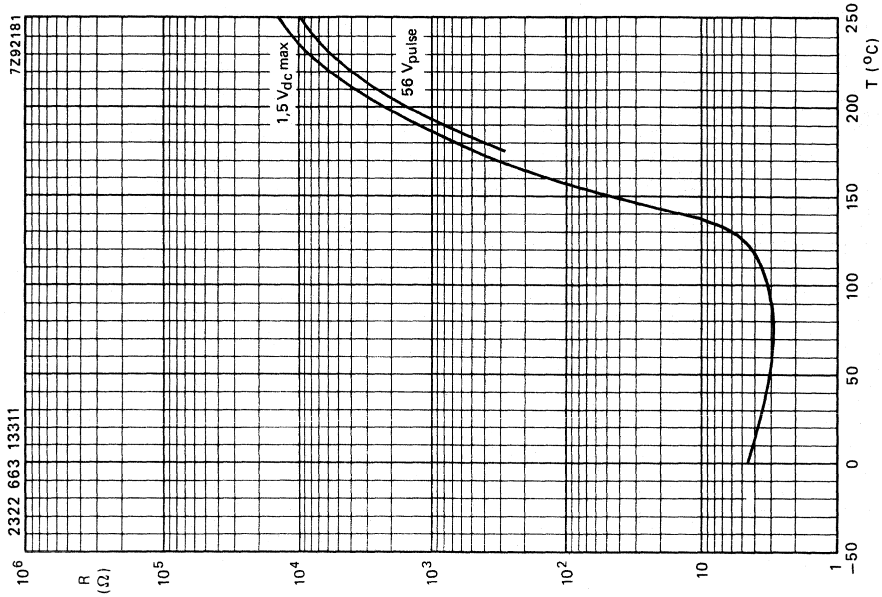


Fig. 11.

Typical resistance/temperature characteristics.

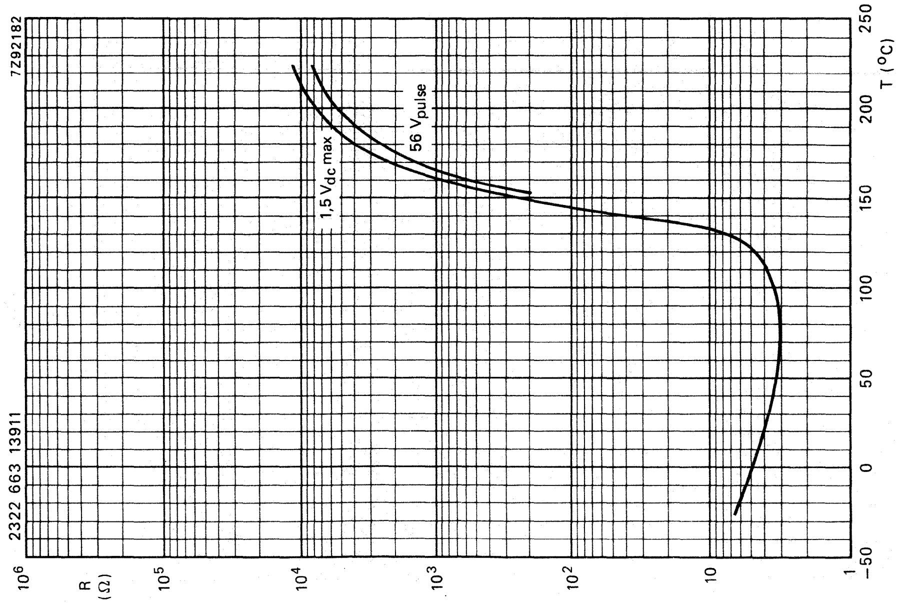


Fig. 12.

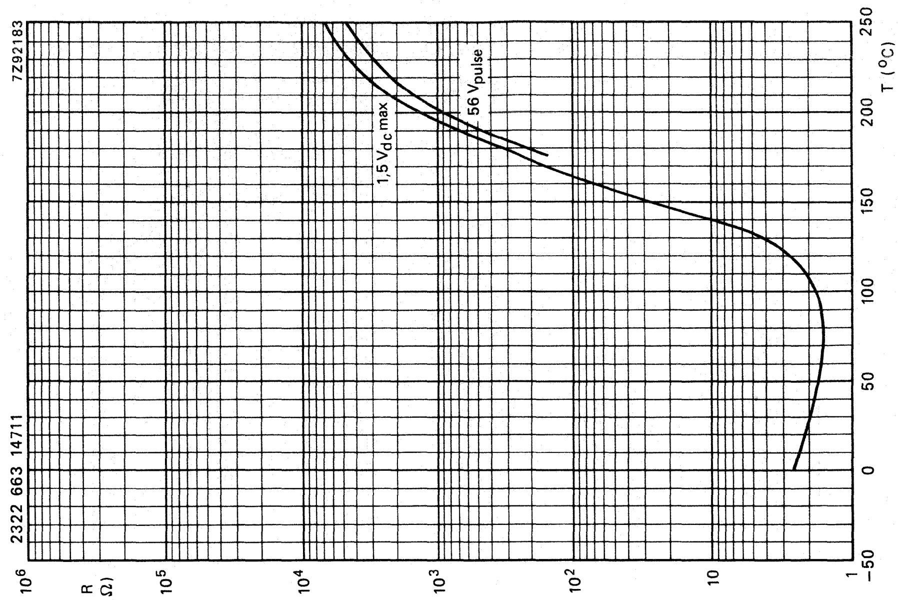


Fig. 13.

Typical resistance/temperature characteristics.

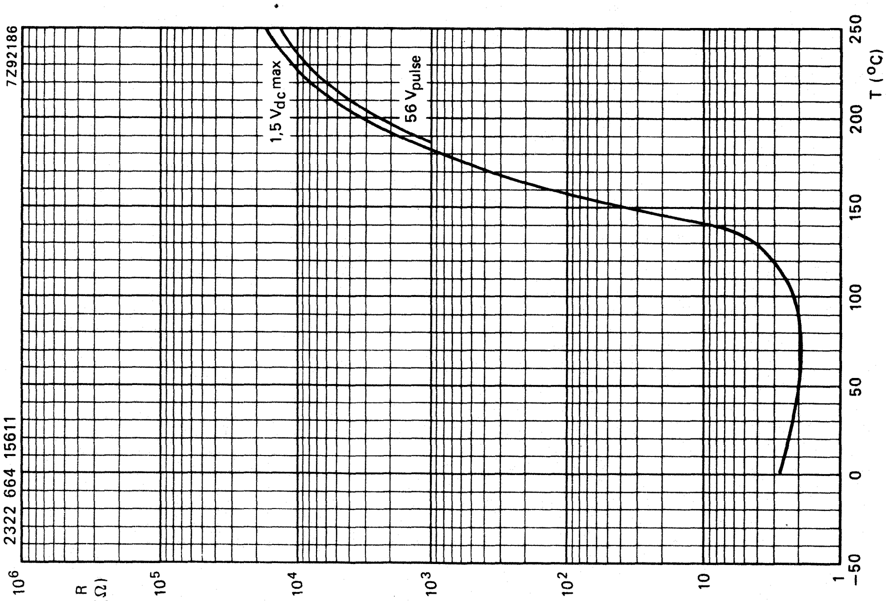


Fig. 14.

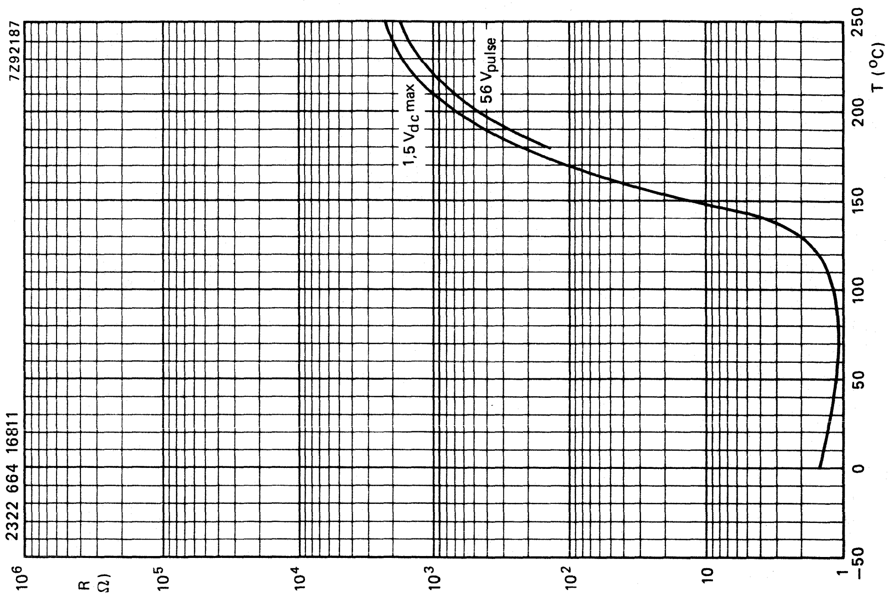


Fig. 15.

Typical resistance/temperature characteristics.

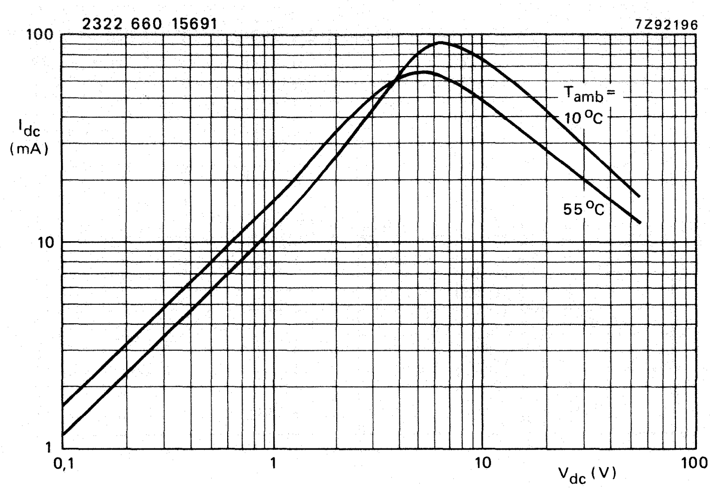


Fig. 16.

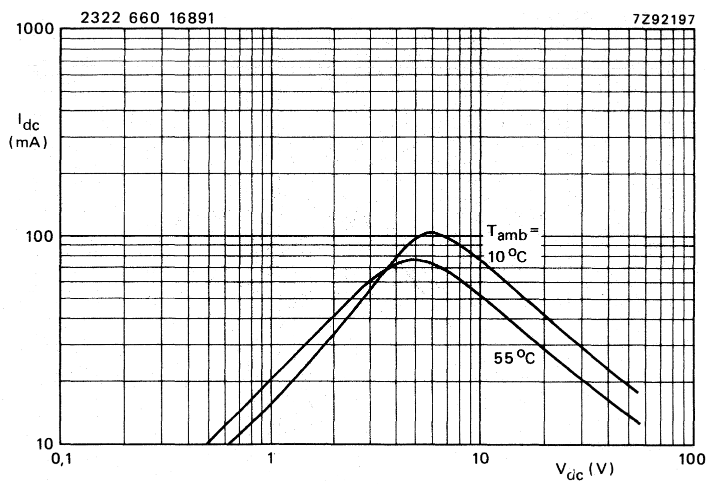


Fig. 17.

Typical voltage/current characteristics.

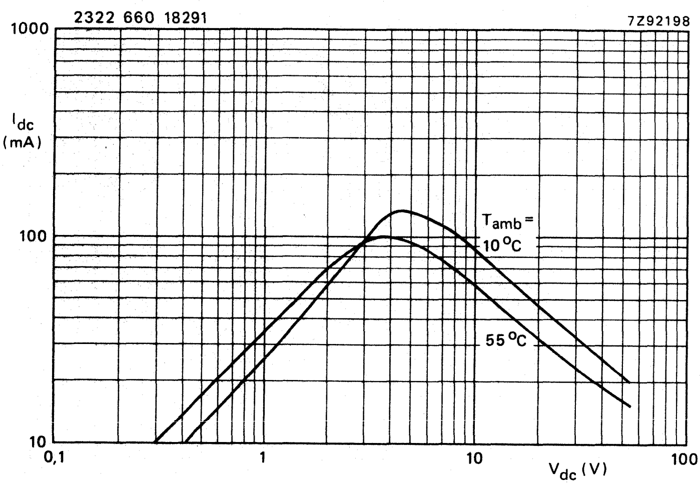


Fig. 18.

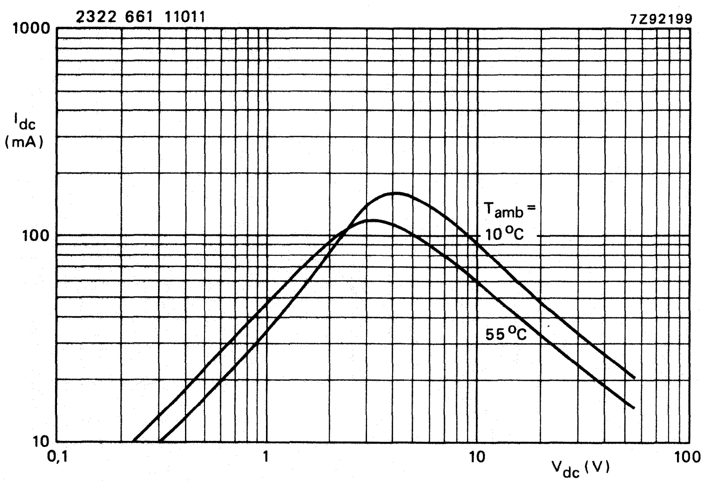


Fig. 19.

Typical voltage/current characteristics.

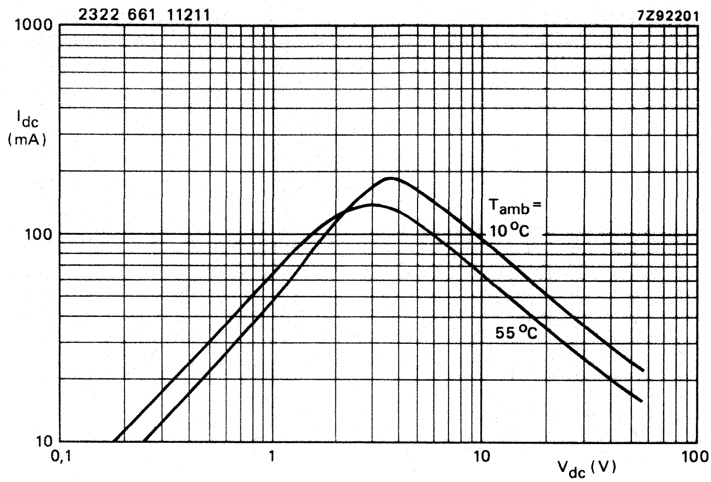


Fig. 20.

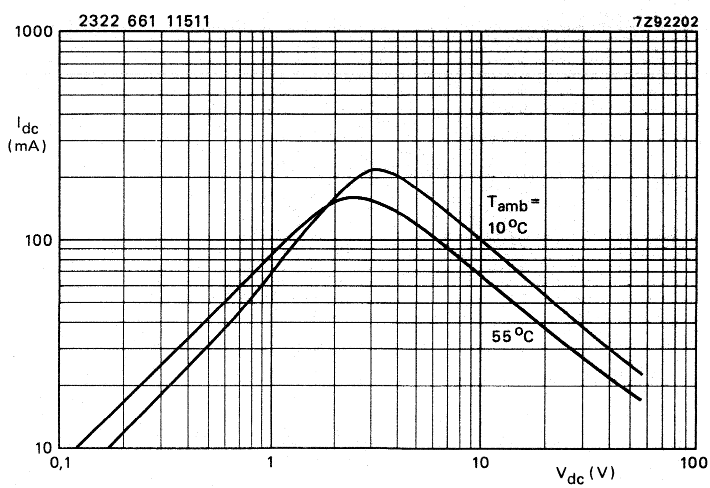


Fig. 21.

Typical voltage/current characteristics.

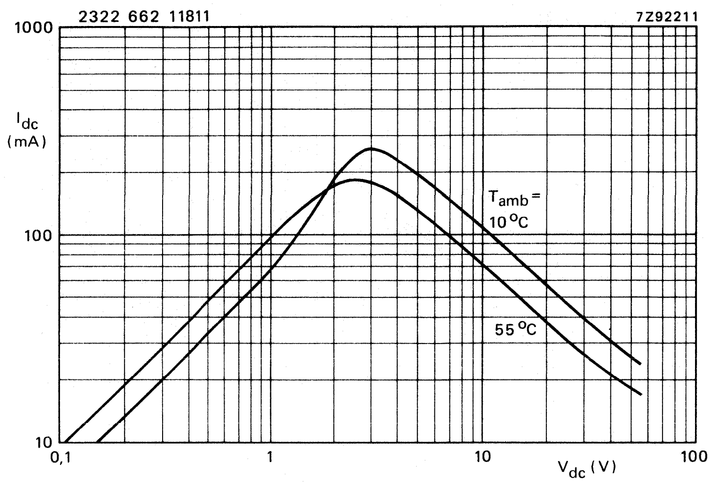


Fig. 22.

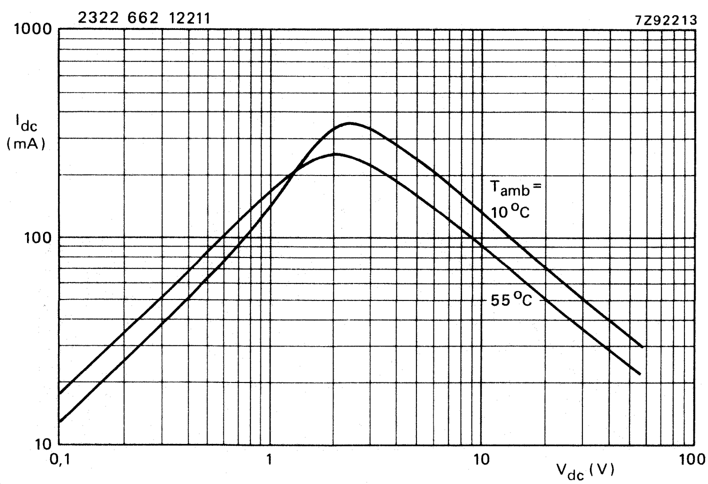


Fig. 23.

Typical voltage/current characteristics.

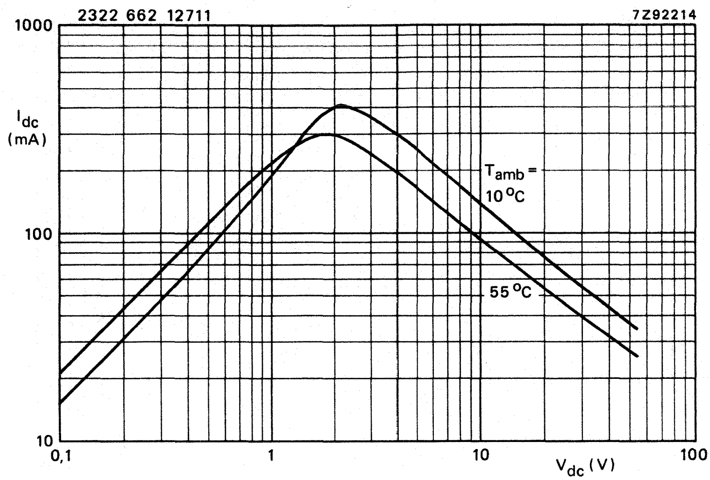


Fig. 24.

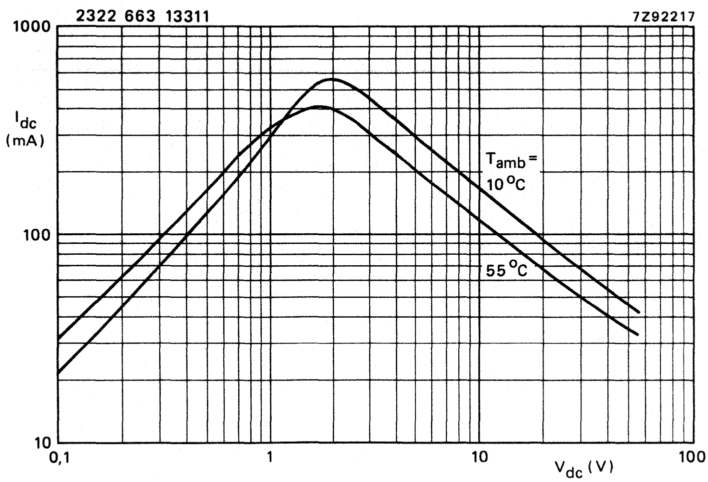


Fig. 25.

Typical voltage/current characteristics.

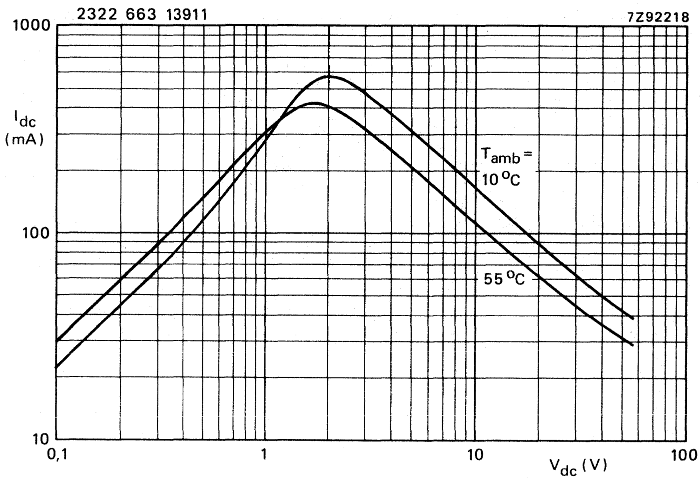


Fig. 26.

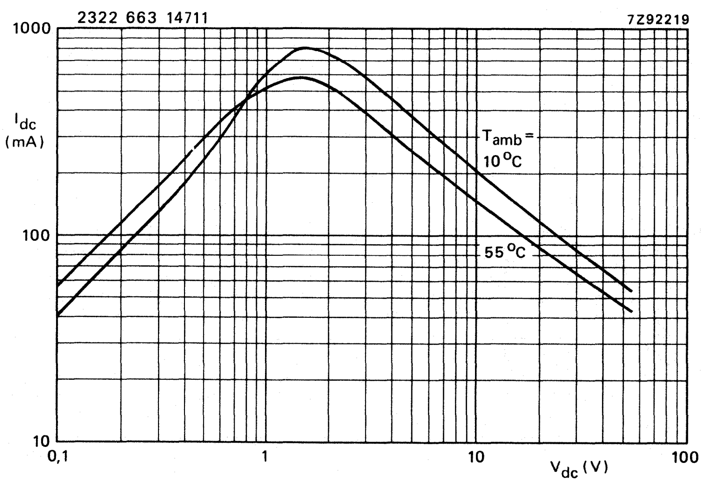


Fig. 27.

Typical voltage/current characteristics.

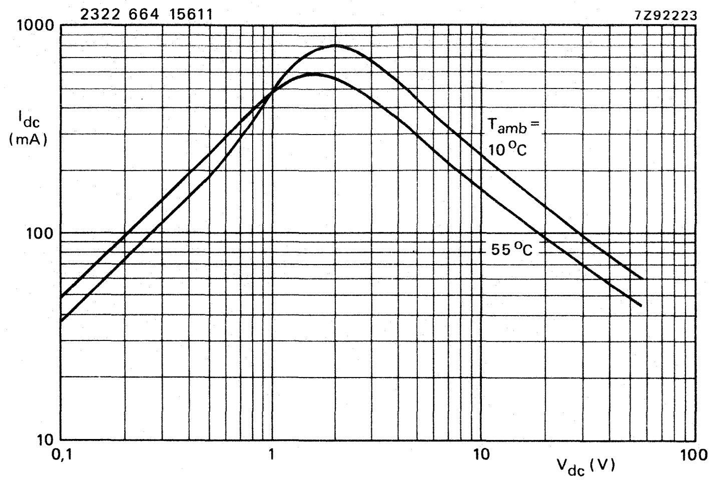


Fig. 28.

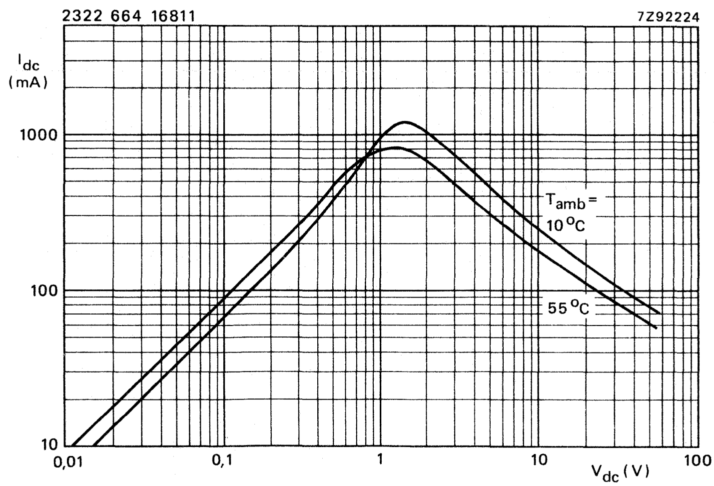


Fig. 29.

Typical voltage/current characteristics.

PTC THERMISTORS

for overload protection

QUICK REFERENCE DATA

Resistance at 25 °C	3,5 to 1900 Ω
Switch temperature	120 °C approximately
Maximum RMS voltage	265 V
Trip current at 10 °C	24 to 940 mA
Operating temperature range at V_{max}	0 to +55 °C

APPLICATION

Overload protection; for use in electrical and electronic equipment such as electric motors, transformers and semiconductor circuits.

DESCRIPTION

These thermistors have a positive temperature coefficient. They consist of a disc with two tinned brass wires, see Fig. 1a. Leadless types having metallized sides for soldering by the user are also available, see Fig. 1b.

MECHANICAL DATA

Outlines

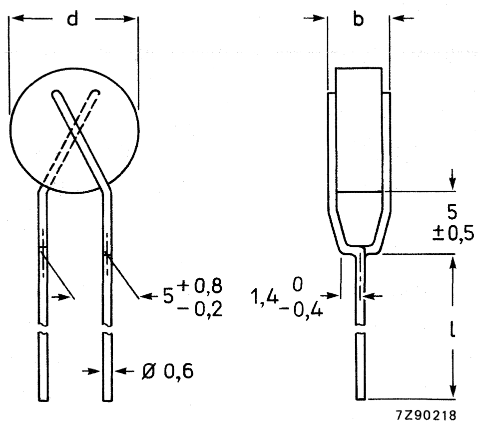


Fig. 1a.

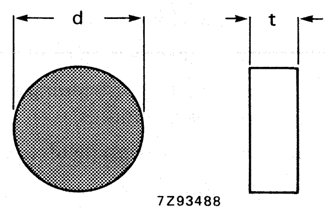


Fig. 1b.

For dimensions b, d, l and t see Table 1.

Marking	None
Mass (types with leads only)	See Table 1
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

When soldering leadless types it is recommended to use a flux containing colofonium and aethyl alcohol only and to pre-heat the discs to approx. 100 °C in order to avoid thermal shocks which might damage the thermistors.

Impact	200 mm free fall
Inflammability	non-flammable

Packaging (for types with leads)

Cardboard boxes containing following items for:

→ 2322 6601 . . . 3:	500	2322 6621 . . . 3:	100
→ 2322 6611 . . . 3:	250	2322 6631 . . . 3:	100
→ 2322 6621 1213:	200	2322 6641 . . . 3:	100

ELECTRICAL DATA

Unless otherwise specified measured according to IEC publication 738-1 (1982)

Maximum current for not tripping at 55 °C (measuring time 5 minutes)	I_{nt}	See Table 1
Minimum current for tripping after 5 minutes at 10 °C	$I_t = 2 \times I_{nt}$	See Table 1
Resistance at + 25 °C	R_{25}	See Table 1
Switch temperature	T_s	≈ 120 °C
Maximum admissible current at 0 °C	I_{max}	See Table 1
Maximum residual current at 265 V (RMS) at 10 °C	$I_{res\ max}$	See Table 1
Maximum RMS voltage with a series resistor		265 V
Series resistor	R_s	See Table 1
Dissipation factor at T_s	D	See Table 1
Heat capacity	H	See Table 1
Operating temperature range		
at zero power		−25 to + 125 °C
at minimum voltage		0 to + 55 °C

DEVELOPMENT DATA

Table 1

catalogue number (see Notes 1 and 2) 2322 followed by	I_{nt} at 55 °C mA	I_t at 10 °C mA	R_{25} approx. Ω	I_{max} at 0 °C mA	$I_{res\,max}$ at 10 °C mA	R_s ± 5% Ω	D approx. mW/K	H approx. J/K	d mm	b max. mm	l ± 3 mm	t max. mm	mass approx. (types with leads only) g
2322 660 .1293	12	24	1900	110	5	1100	6	0,12	4,5	5	20	2,9	0,45
660 .1593	15	30	1200	135	5	1100	6	0,12	4,5	5	20	2,9	0,45
660 .1893	18	36	850	165	5	1000	6	0,12	4,5	5	20	2,9	0,45
660 .2293	22	44	560	200	6	910	6	0,12	4,5	5	20	2,9	0,45
660 .2793	27	54	380	250	6	820	6	0,12	4,5	5	20	2,9	0,45
661 .3393	33	66	280	290	7	750	7	0,22	6,5	5	20	2,9	0,70
661 .3993	39	78	200	350	7	620	7	0,22	6,5	5	20	2,9	0,70
661 .4793	47	94	140	420	7	560	7	0,22	6,5	5	20	2,9	0,70
661 .5693	56	112	100	500	8	470	7	0,22	6,5	5	20	2,9	0,70
661 .6893	68	136	72	600	8	390	8	0,33	8,0	5	20	2,9	0,90
661 .8293	82	164	50	730	9	330	8	0,33	8,0	5	20	2,9	0,90
661 .1013	100	200	33	900	9	270	8	0,33	8,0	5	20	2,9	0,90
662 .1213	120	240	26	1100	12	220	8,5	0,48	10,0	5	20	2,9	1,30
662 .1513	150	300	20	1300	12	200	9,5	0,68	12,0	5	20	2,9	1,80
662 .1813	180	360	14	1700	14	150	9,5	0,68	12,0	5	20	2,9	1,80
663 .2213	220	440	10	2100	16	120	10	0,85	13,0	5	20	2,9	2,15
663 .2713	270	540	8	2500	19	100	12	1,30	16,0	5	20	2,9	2,90
664 .3313	330	660	7	3000	25	82	16	2,40	20,0	6	16	3,6	5,30
664 .3913	390	780	5	3600	25	68	16	2,40	20,0	6	16	3,6	5,30
664 .4713	470	940	3,5	4300	25	56	16	2,40	20,0	6	16	3,6	5,30

Notes to Table 1

1. For leadless types, replace the dot in the catalogue number by 0; for types with leads, replace it by 1.
2. For taped devices up to 12 mm in diameter, replace the dot by 3.

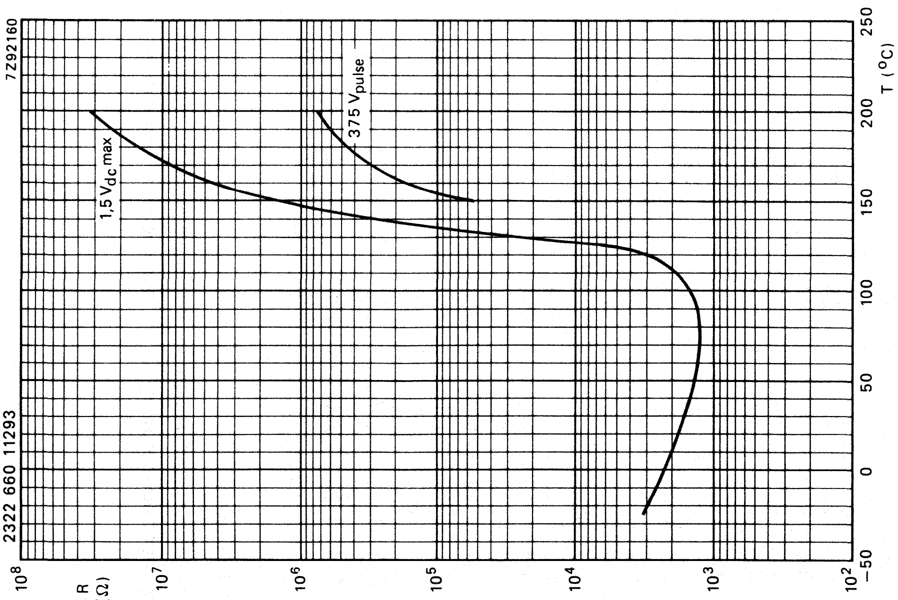


Fig. 2.

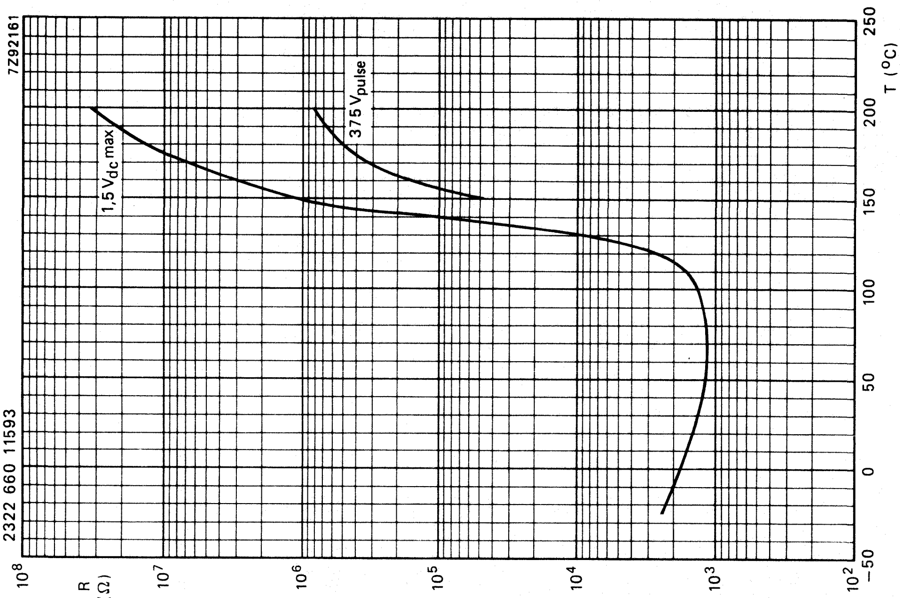


Fig. 3.

Typical resistance/temperature characteristics.

DEVELOPMENT DATA

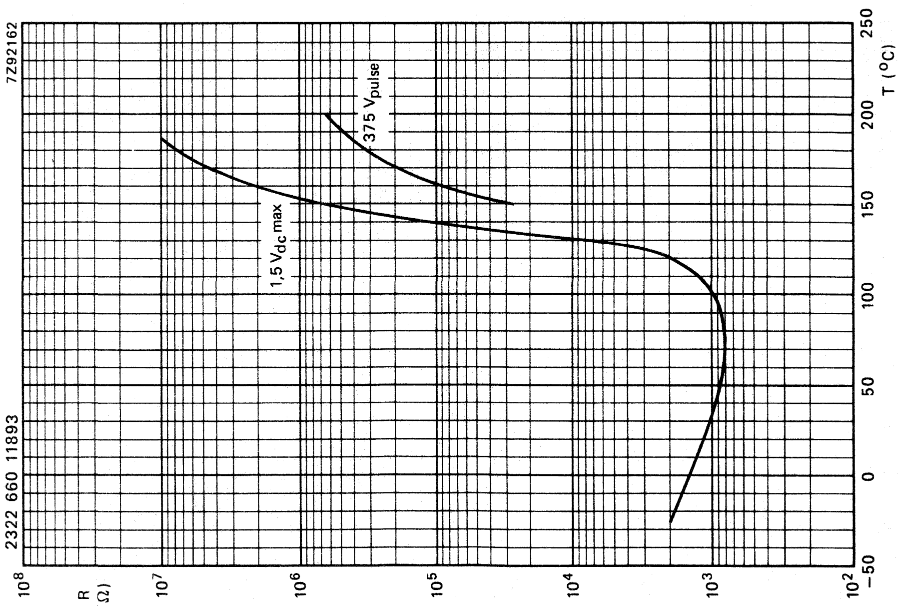


Fig. 4.

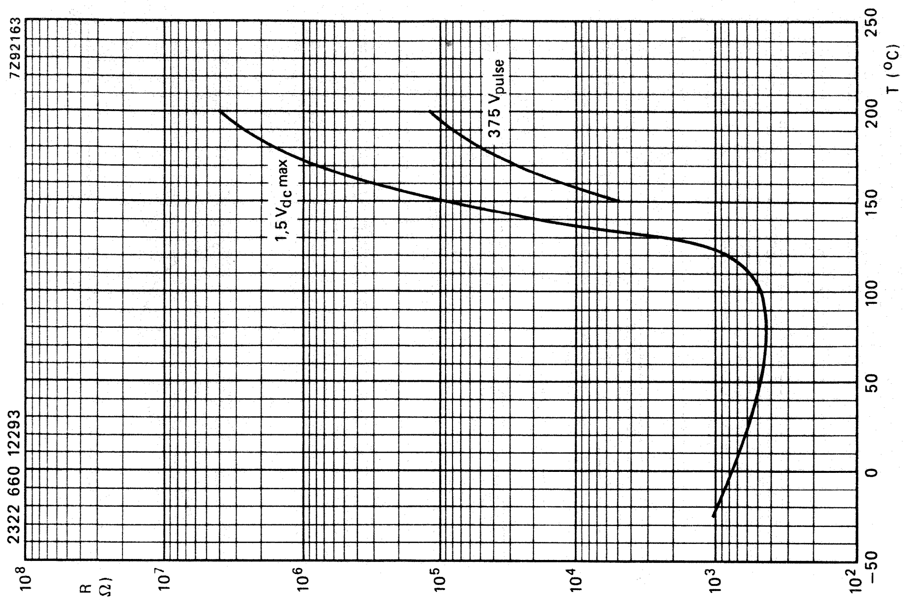


Fig. 5.

Typical resistance/temperature characteristics.

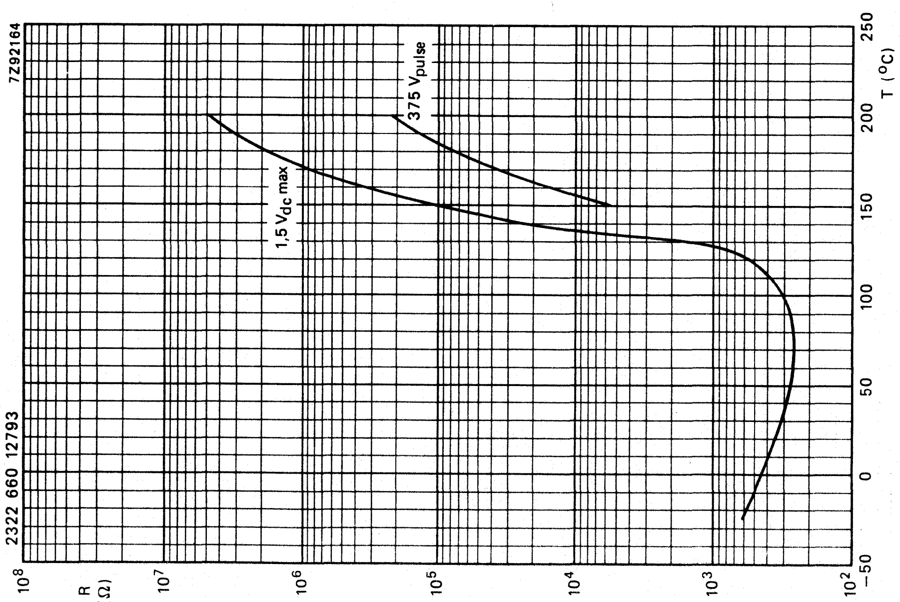


Fig. 6.

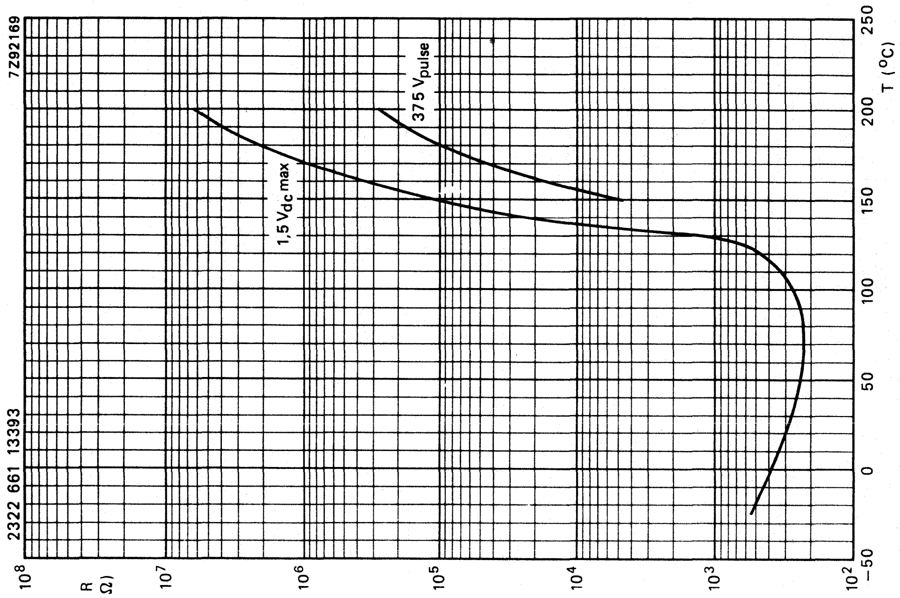


Fig. 7.

Typical resistance/temperature characteristics.

DEVELOPMENT DATA

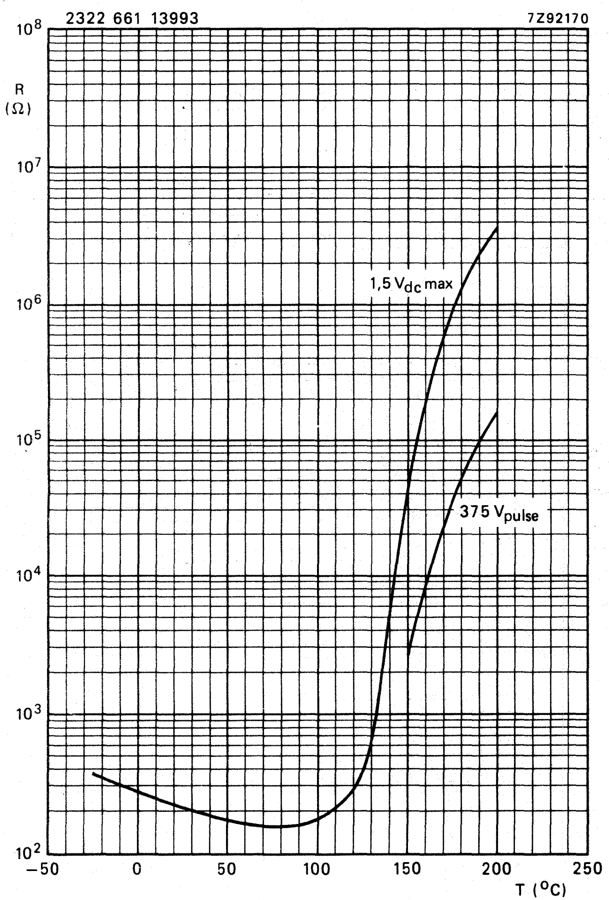


Fig. 8.

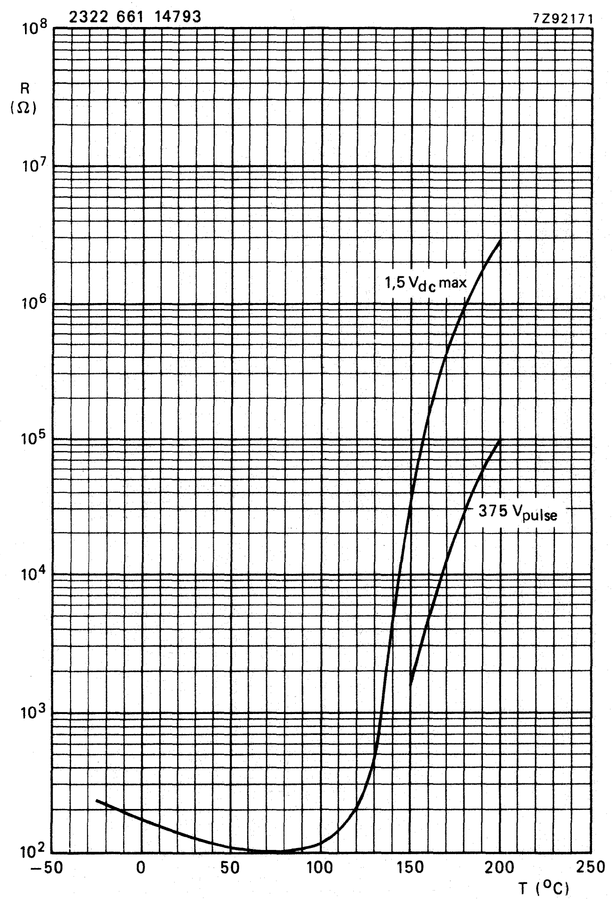


Fig. 9.

Typical resistance/temperature characteristics.

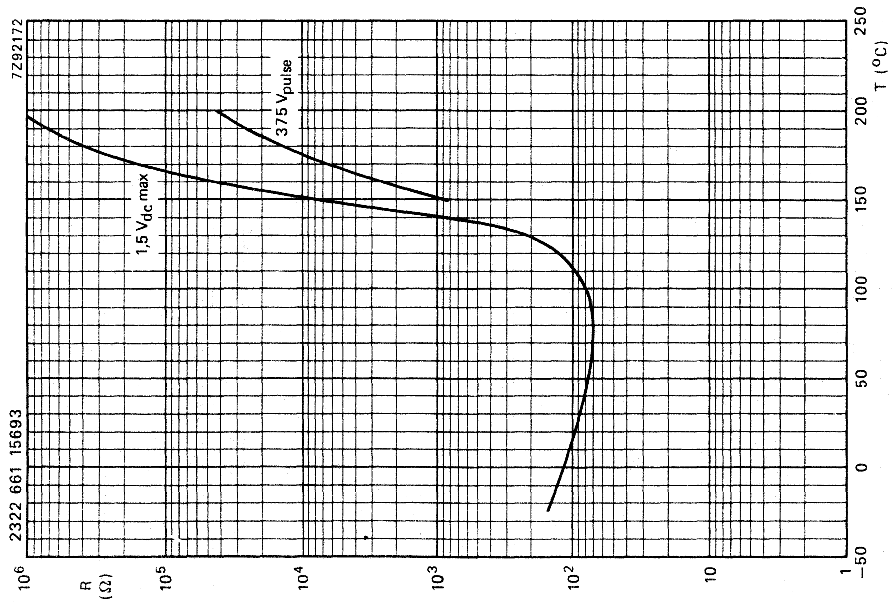


Fig. 10.

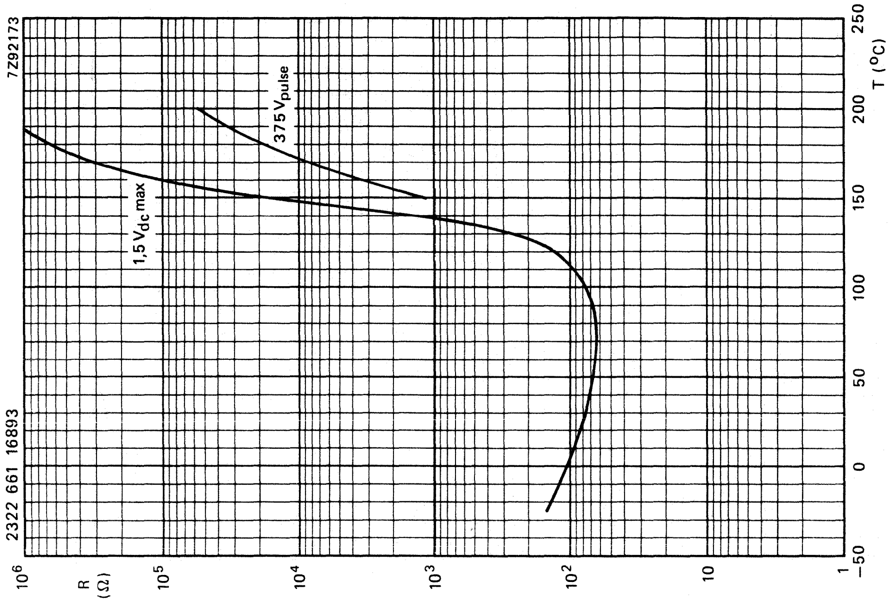


Fig. 11.

Typical resistance/temperature characteristics.

DEVELOPMENT DATA

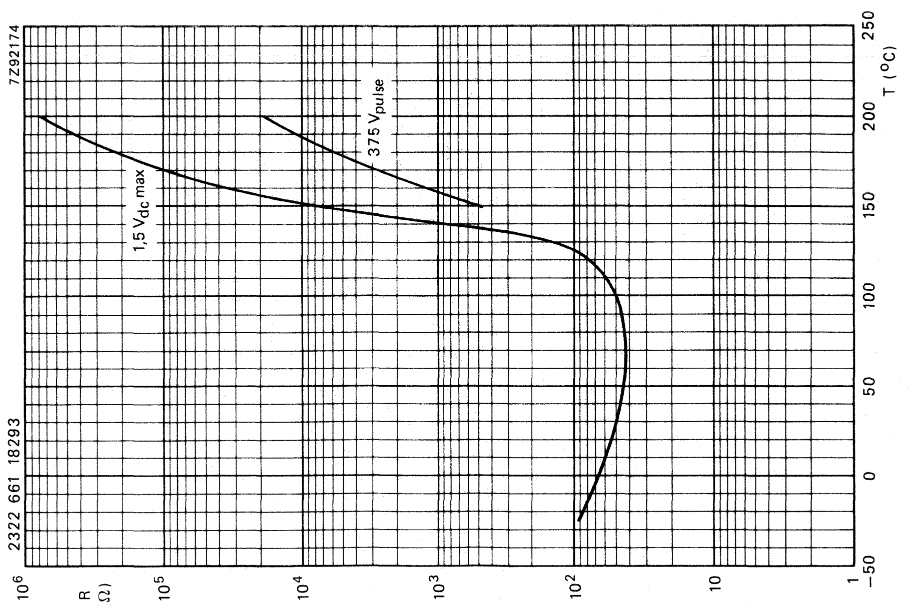


Fig. 12.

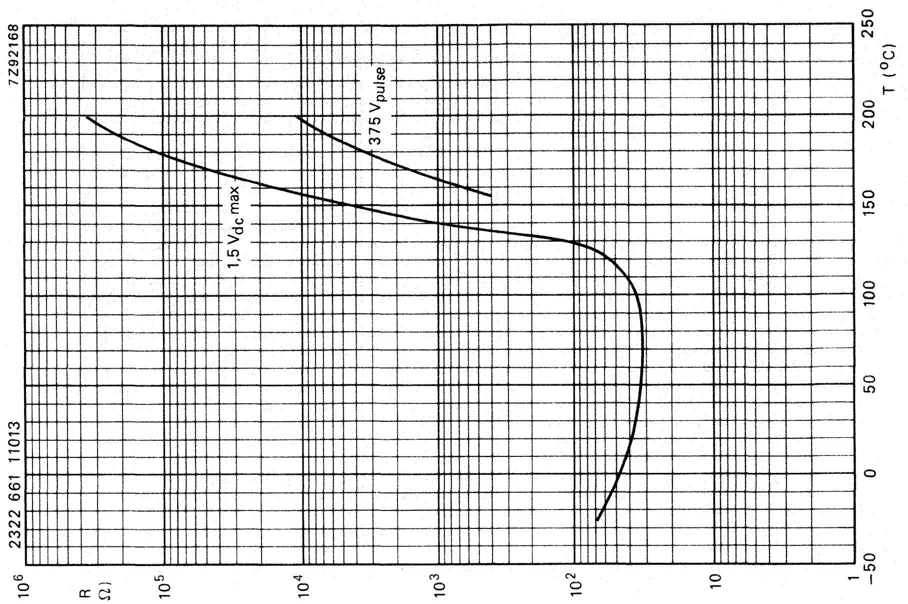


Fig. 13.

Typical resistance/temperature characteristics.

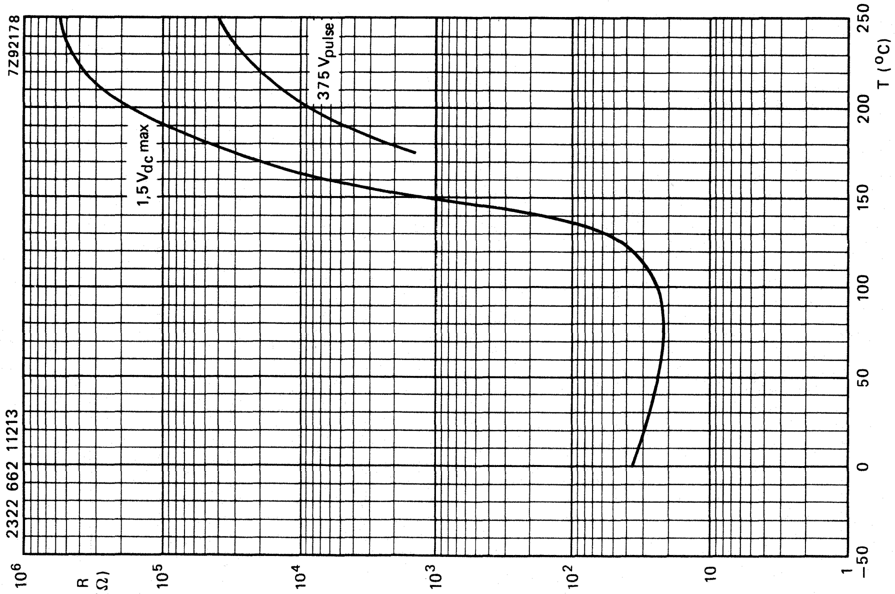


Fig. 14.

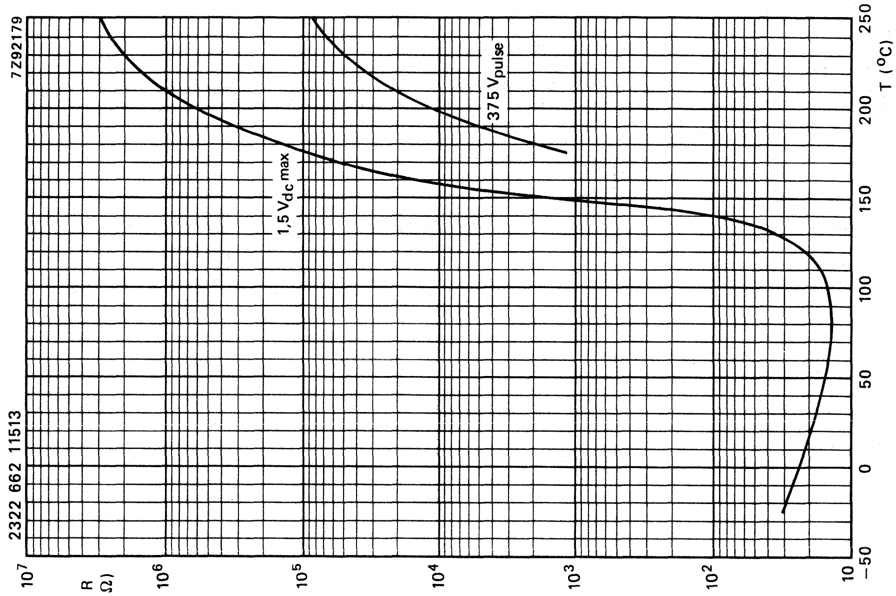


Fig. 15.

Typical resistance/temperature characteristics.

DEVELOPMENT DATA

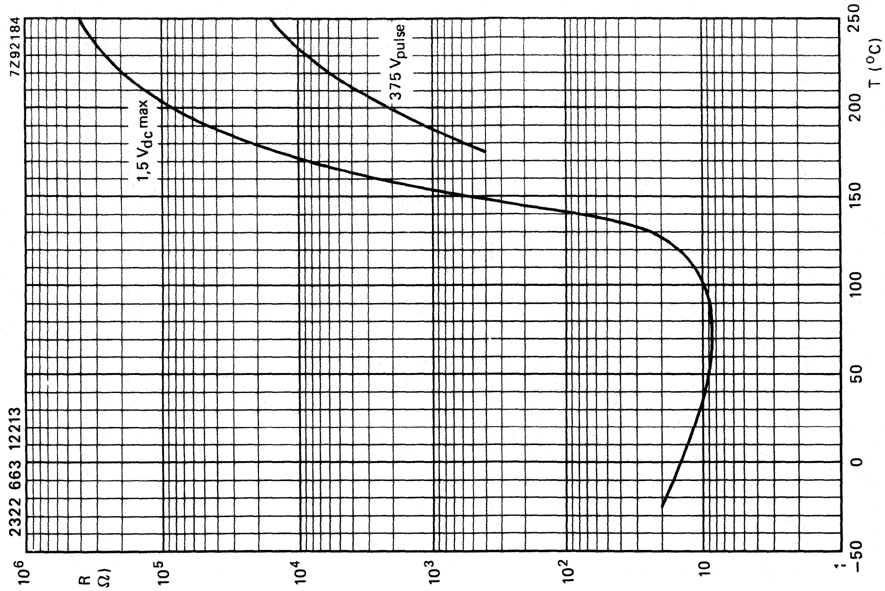


Fig. 17.

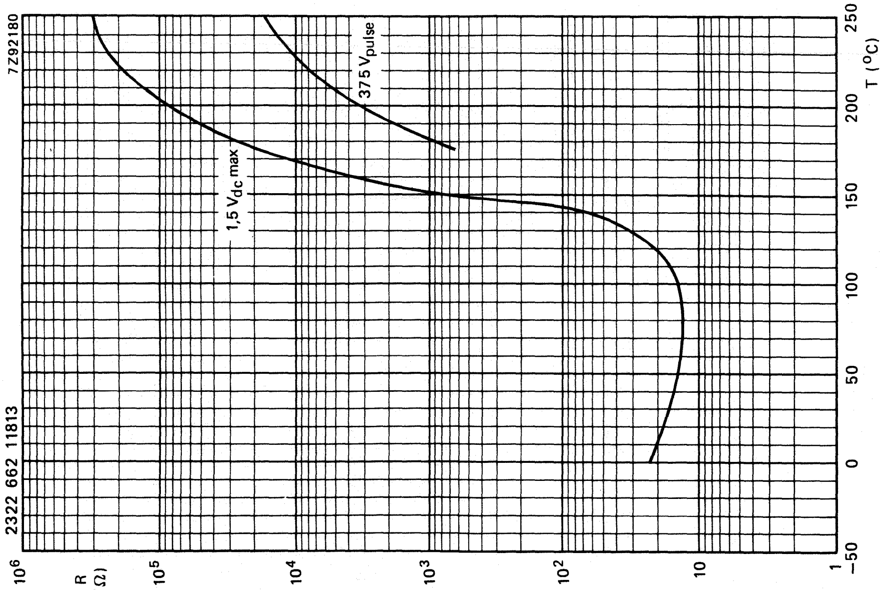


Fig. 16.

Typical resistance/temperature characteristics.

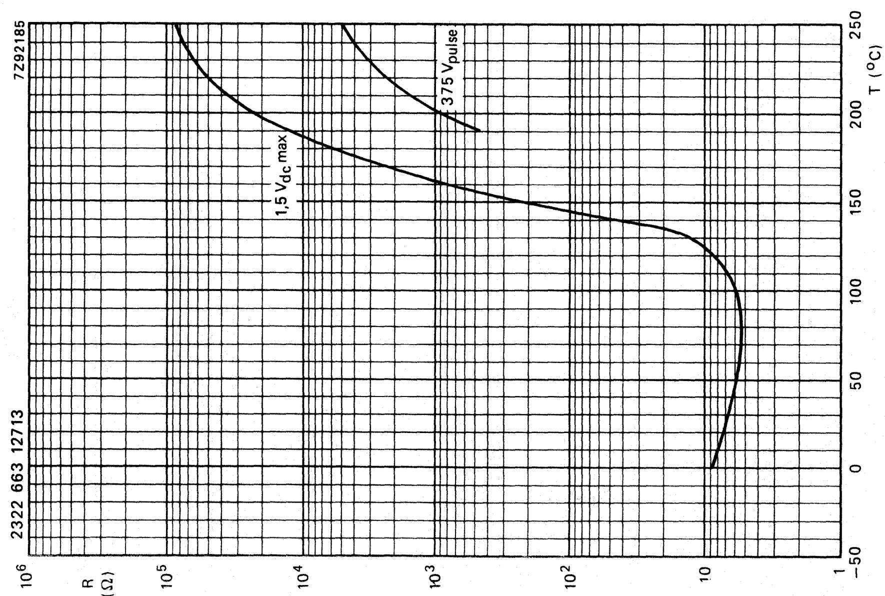


Fig. 18.

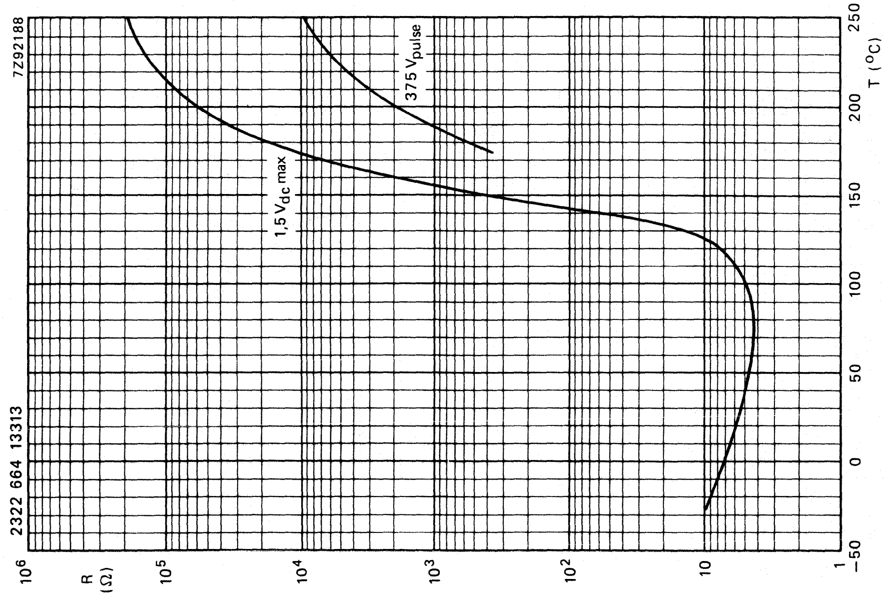


Fig. 19.

Typical resistance/temperature characteristics.

DEVELOPMENT DATA

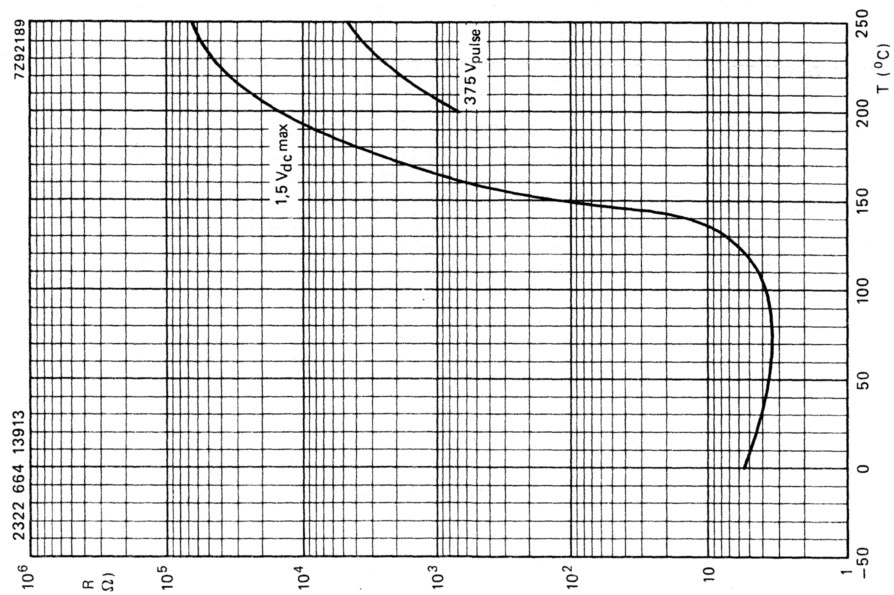


Fig. 20.

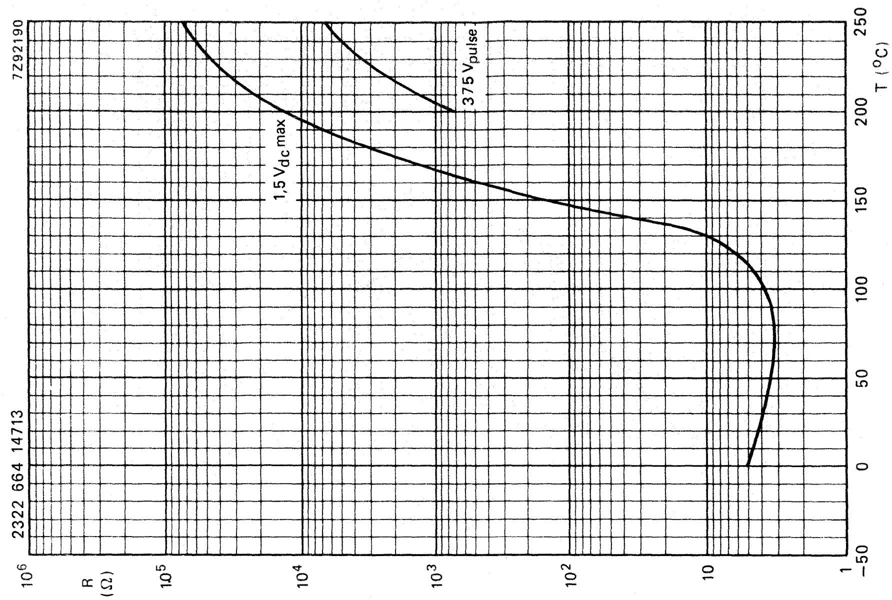


Fig. 21.

Typical resistance/temperature characteristics.

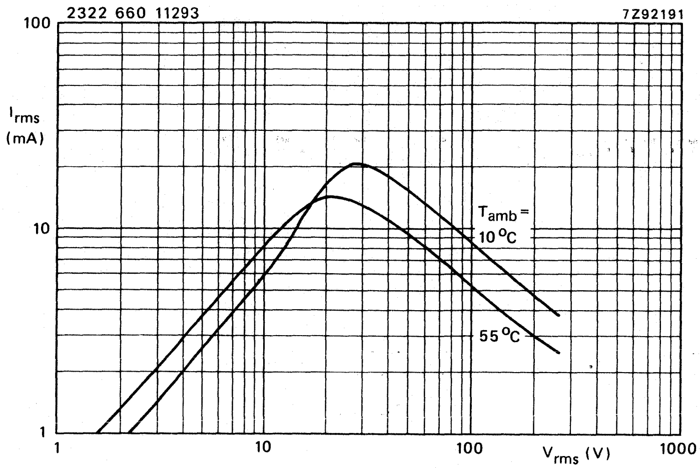


Fig. 22.

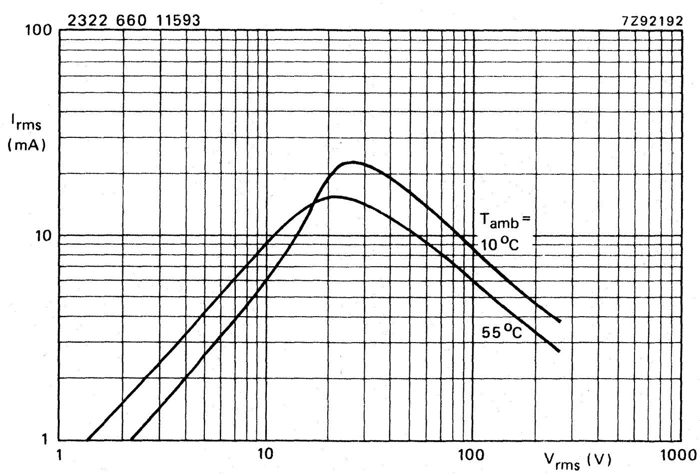


Fig. 23.

Typical voltage/current characteristics.

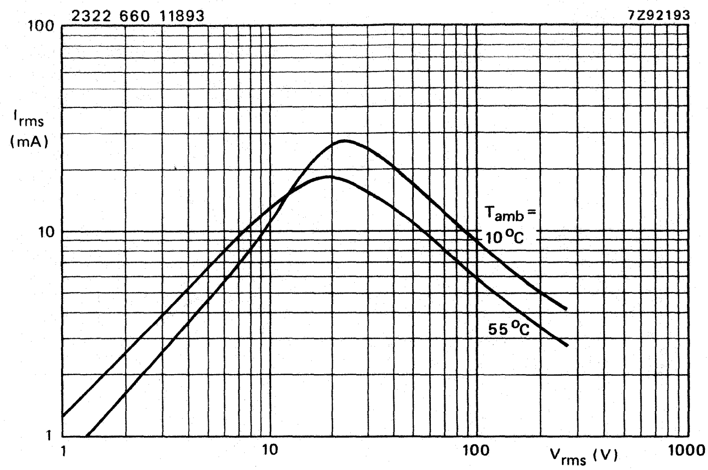


Fig. 24.

DEVELOPMENT DATA

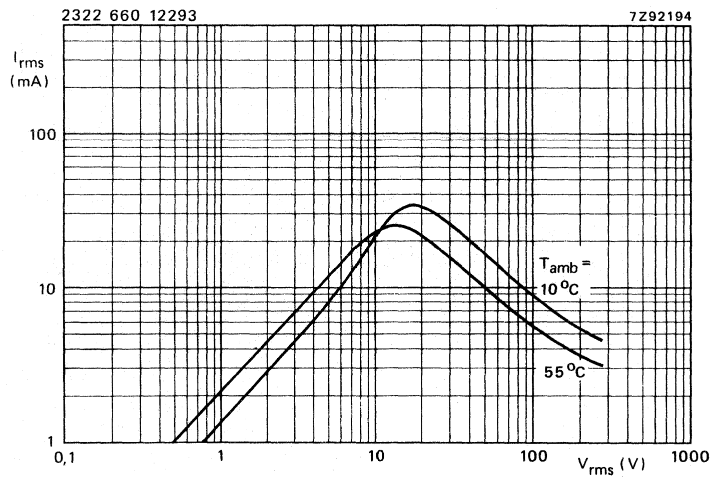


Fig. 25.

Typical voltage/current characteristics.

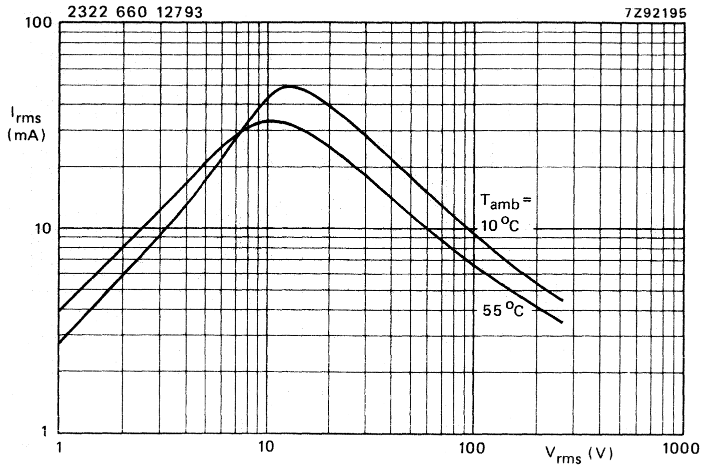


Fig. 26.

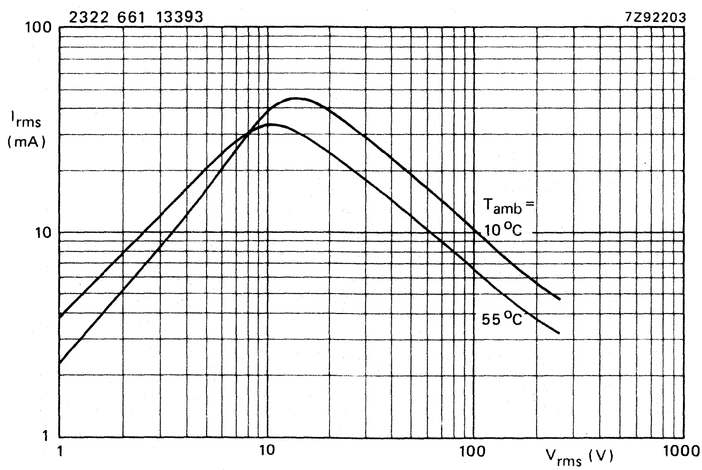


Fig. 27.

Typical voltage/current characteristics.

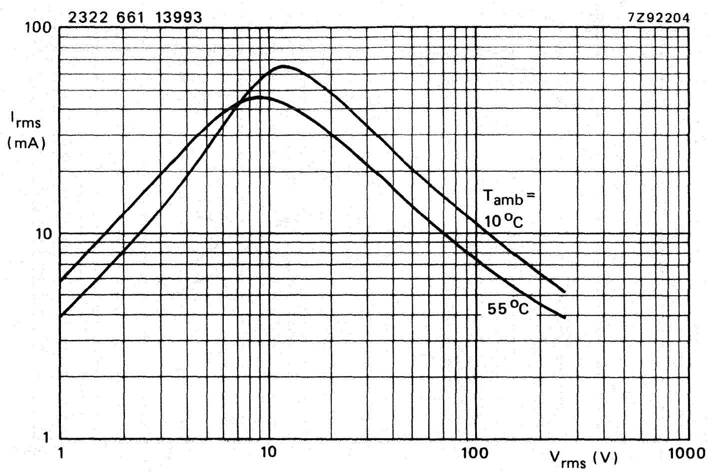


Fig. 28.

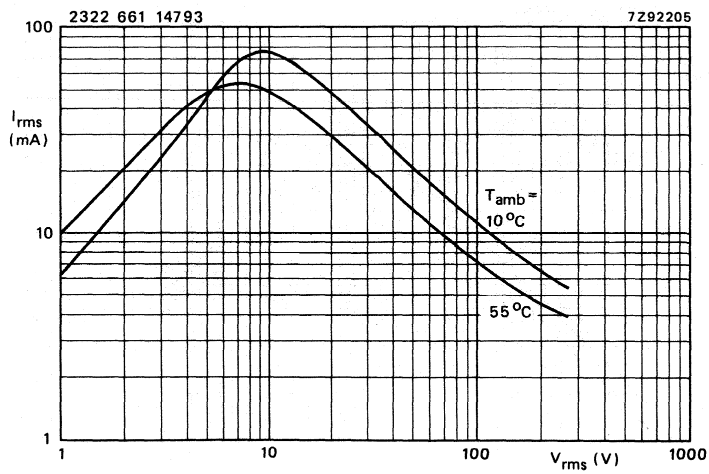


Fig. 29.

Typical voltage/current characteristics.

DEVELOPMENT DATA

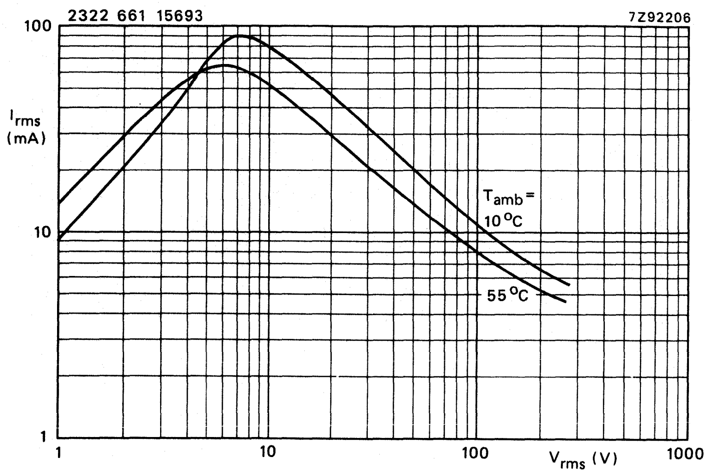


Fig. 30.

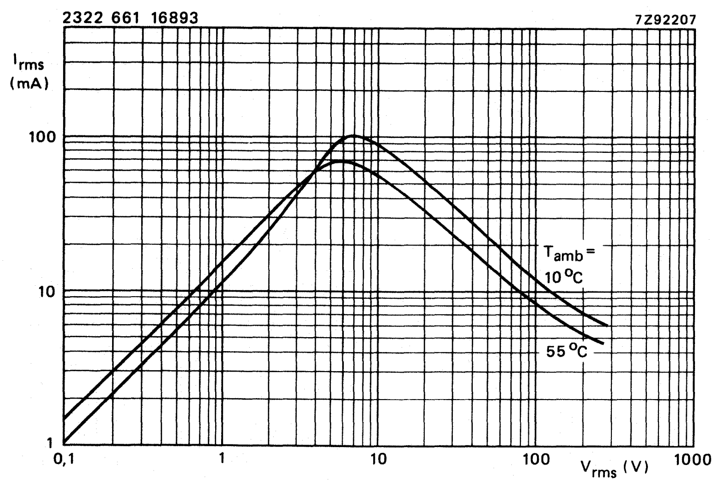


Fig. 31.

Typical voltage/current characteristics.

DEVELOPMENT DATA

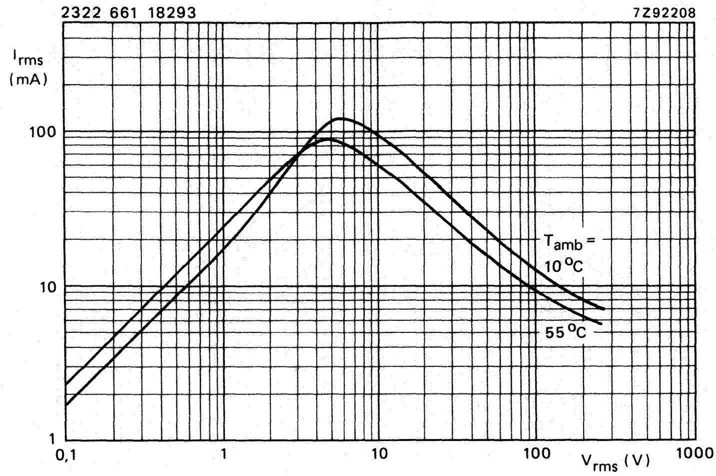


Fig. 32.

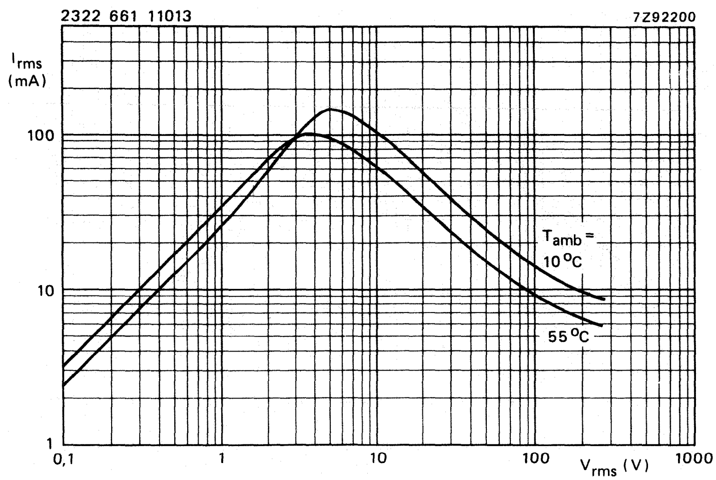
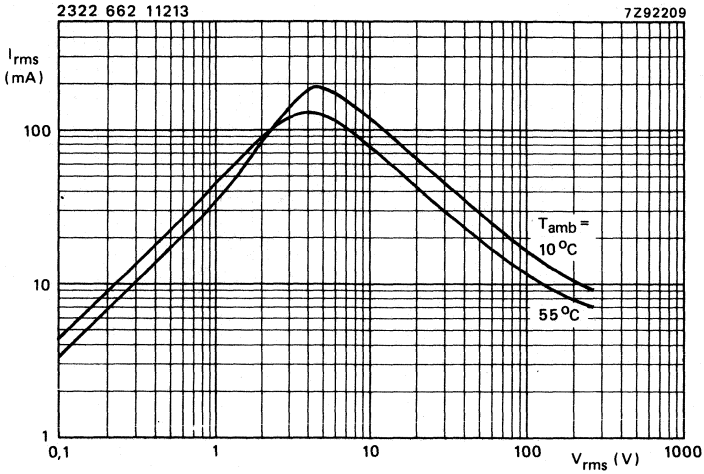


Fig. 33.

Typical voltage/current characteristics.



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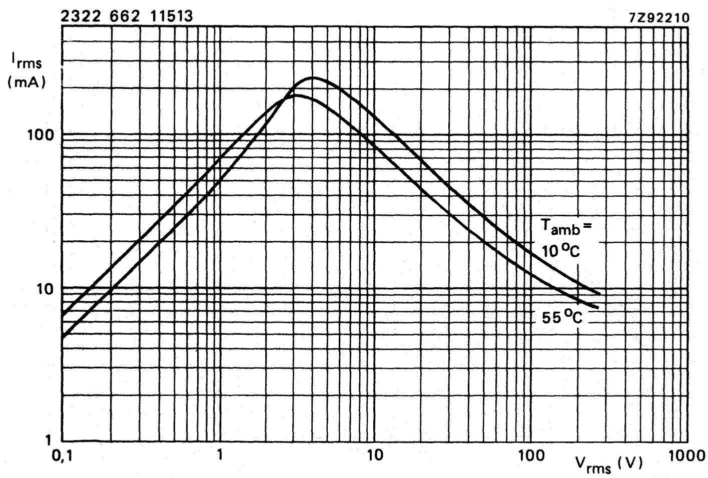


Fig. 35.

Typical voltage/current characteristics.

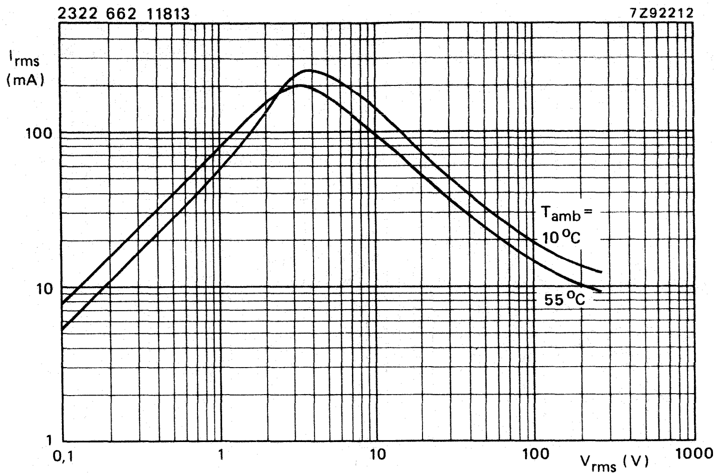


Fig. 36.

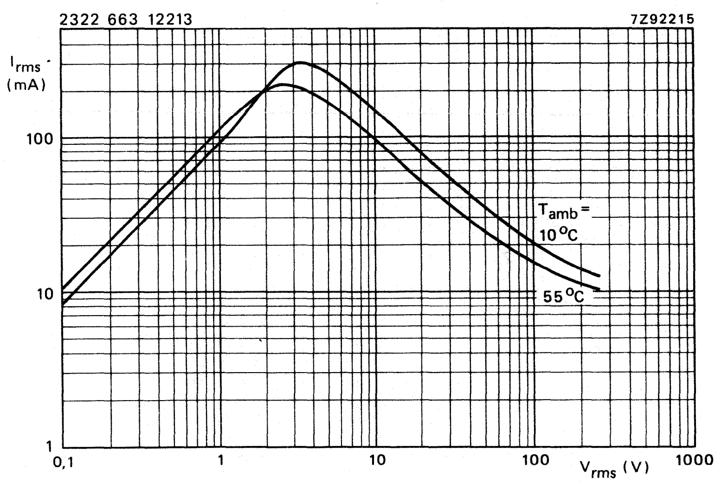


Fig. 37.
Typical voltage/current characteristics.

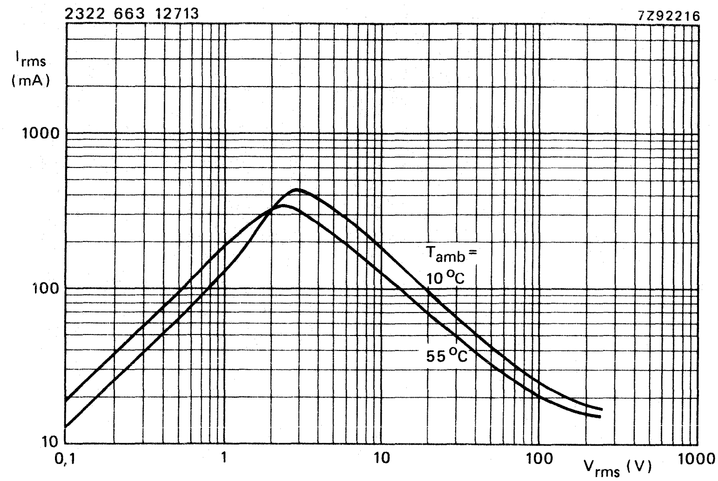


Fig. 38.

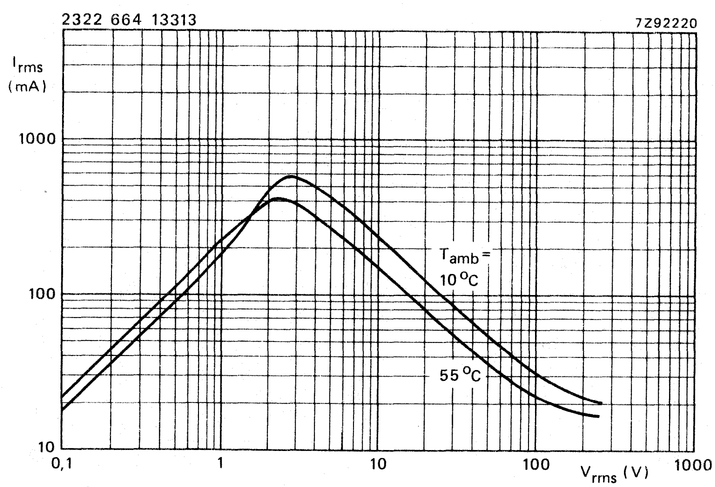


Fig. 39.

Typical voltage/current characteristics.

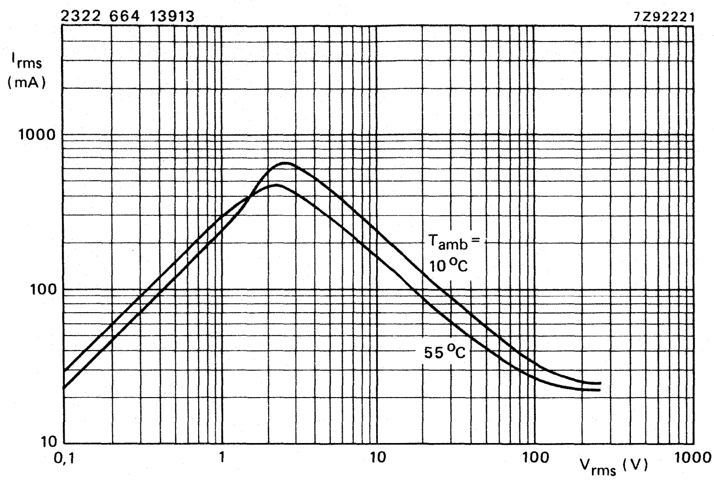


Fig. 40.

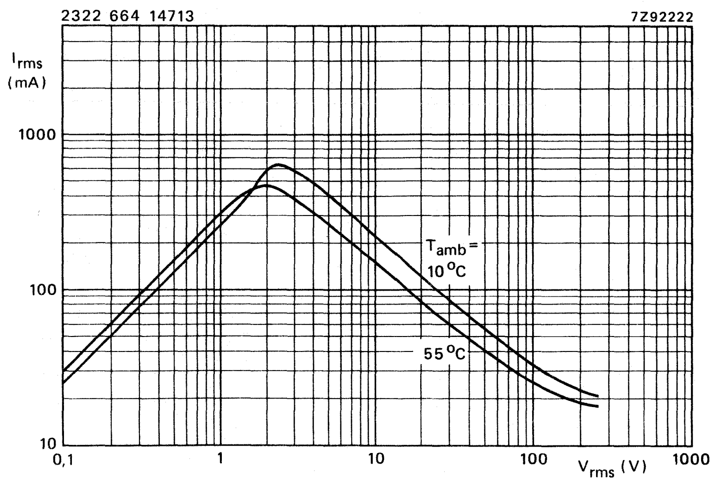


Fig. 41.

Typical voltage/current characteristics.

PTC THERMISTORS

for overload protection

QUICK REFERENCE DATA

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

APPLICATION

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

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

DESCRIPTION

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

MECHANICAL DATA

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

Table 1 Outlines

Dimensions in mm

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

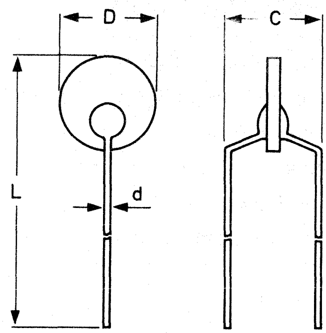


Fig. 1.

2322 660 91017	4,5	52,5	4	0,5	0,4
2322 660 93006	4,5	52,5	5,5	0,5	0,5
2322 660 93011	4,5	52,5	5,5	0,5	0,5
2322 660 93012	4,5	52,5	5,5	0,5	0,5
2322 660 93013	4,5	52,5	5,5	0,5	0,5
2322 660 93014	4,5	52,5	5,5	0,5	0,5
2322 661 91021	8	54	4	0,5	0,6
2322 661 93002	8	54	5,5	0,5	1,0
2322 662 91005	10	55	4	0,5	0,7
2322 662 91007	12	56	4	0,5	0,9
2322 662 93016	10	55	5,5	0,5	1,4
2322 662 93018	12	56	5,5	0,5	1,8
2322 663 91003	16	58	4	0,5	1,4
2322 663 93007	16	58	5,5	0,5	3,0
2322 664 91003	20	60	4	0,5	1,9
2322 664 93015	20	60	5,5	0,5	4,6
2322 672 91016	3	51,5	4	0,5	0,25
2322 672 93003	3	51,5	5,5	0,5	0,3

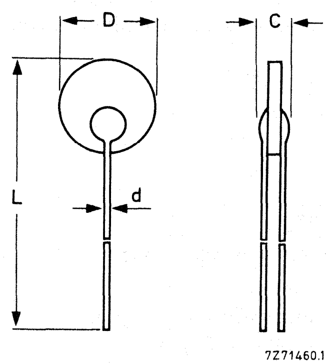


Fig. 2.

ELECTRICAL DATA

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

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

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

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

Definitions of terms used in Tables 2 and 3.

V_{max}	max. d.c. or a.c. voltage at + 55 °C.
$I_{stat\ peak}$	max. stationary operating current.
I_{max}	max. current at T_{amb} = 0 °C.
I_{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}.

PTC THERMISTOR

QUICK REFERENCE DATA

Resistance	
at +25 °C	120 ± 30 Ω
at + 200 °C	> 6 kΩ
Switch temperature	145 °C approx.
Temperature coefficient	> 8%/K
Maximum voltage (DC) at +40 °C	34 V
Response time	⩽ 2 s
Operating temperature range	
at zero power	−25 to + 155 °C
at maximum voltage	0 to +40 °C

APPLICATION

Current stabilizer for compensation of variation in telephone line resistance.

DESCRIPTION

A miniature thermistor element mounted in a glass envelope model DO-7 with two axial leads.

MECHANICAL DATA

Outlines

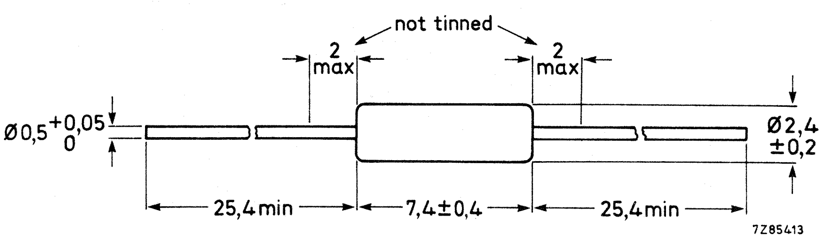
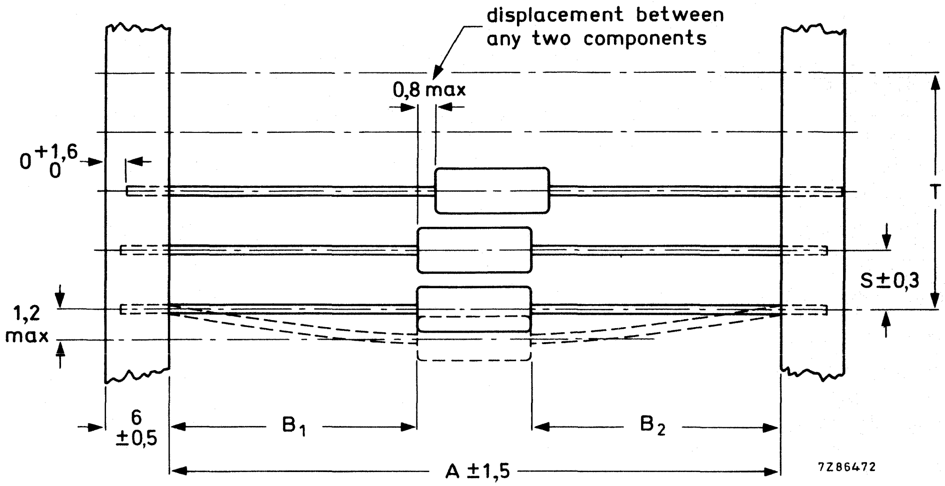


Fig. 1 Component outline.

STANDARD PACKAGING

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

Configuration of bandolier



style	A	B1 -- B2 ± max.	S (spacing)	T (max. deviation of spacing)
TPJ	53	1,2	5	2 mm for 10 spacings, 1,5 mm for 5 spacings

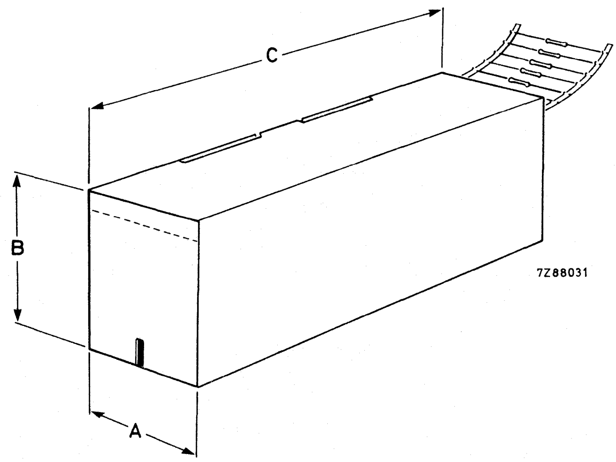


Fig. 3 Dimensions of ammopack in mm.

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

PTC THERMISTORS

disc

QUICK REFERENCE DATA

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

APPLICATION

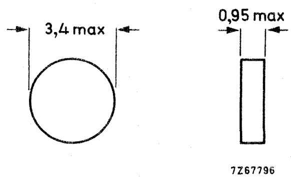
Temperature sensors in domestic appliances, fire alarms, car electronics, etc.

DESCRIPTION

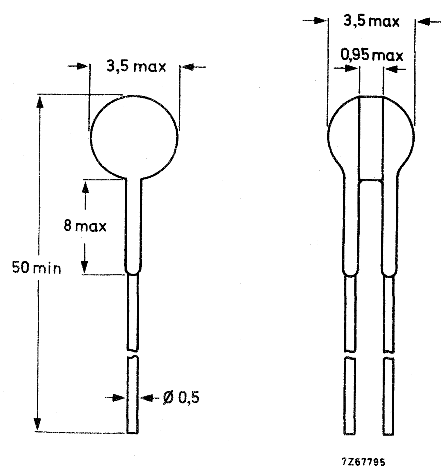
These thermistors have a positive temperature coefficient. They consist of a disc with or without two tinned copper wires. The thermistor without leads is not lacquered nor insulated. The thermistor with leads is lacquered but not insulated.

MECHANICAL DATA

Outlines



version without leads.



version with leads

Fig. 1.

Marking

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

Mass

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

Mounting (for version with leads only)

In any position by soldering.

Robustness of terminations (for version with leads only)

→ Tensile strength	5 N
→ Bending	2,5 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 1000 mm

PACKAGING

Version without leads: 5000 thermistors in a cardboard box.
Version with leads: 500 thermistors in a cardboard box.

ELECTRICAL DATA

All values without further indication are approximate values.

T_s °C	temperature coefficient %/K	colour code for version with leads	catalogue number 2322 672 ..... with leads	catalogue number 2322 672 ..... without leads
70	18	violet	91002	91026
80	21	grey	91003	91027
90	31	white	91004	91028
100	33	black	91005	91029
110	38	brown	91006	91031
120	27	red	91007	91032
130	33	orange	91008	91033
140	33	yellow	91009	91034
150	23	green	91011	91035

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

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

Typical resistance/temperature characteristics

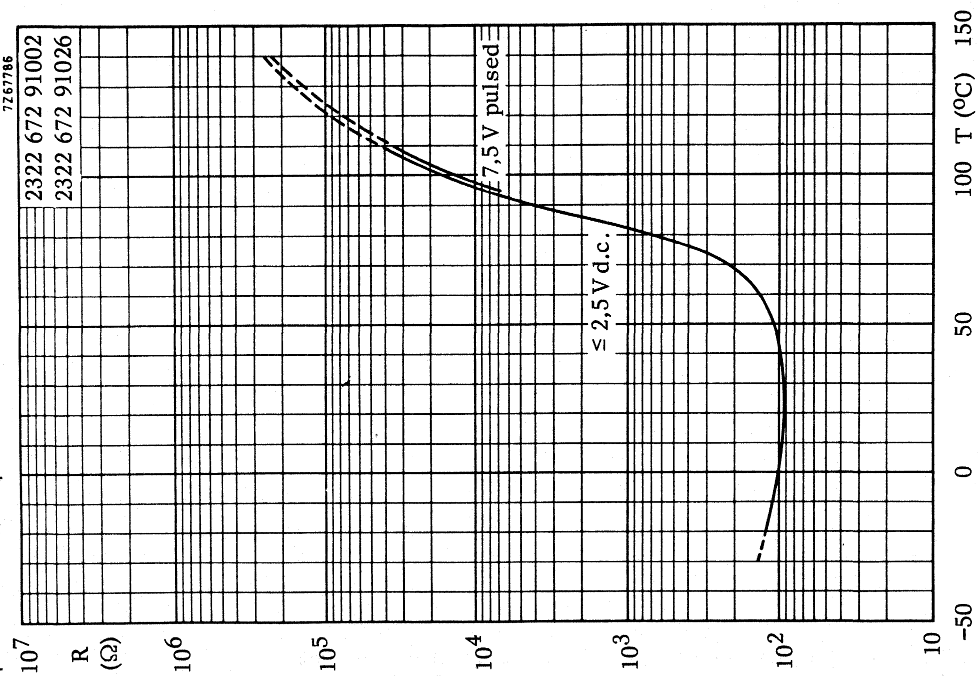


Fig. 2.

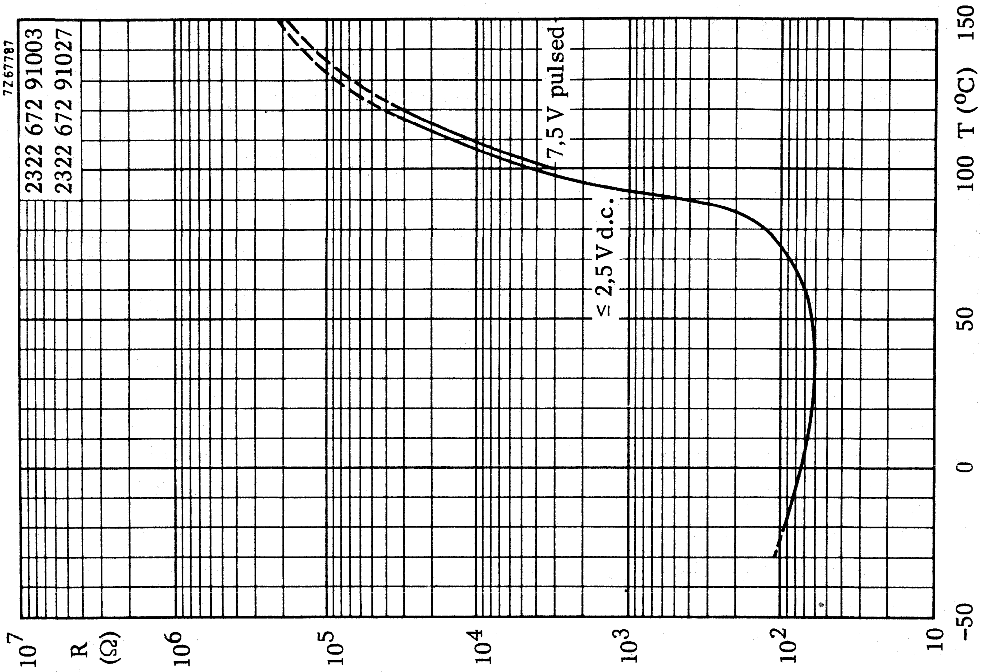


Fig. 3.

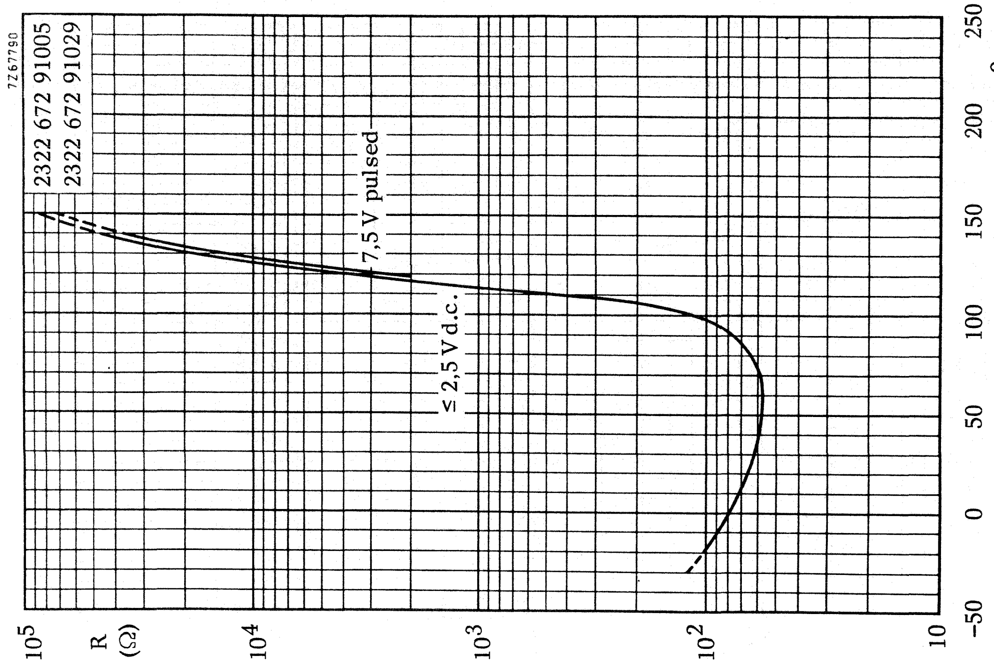

7Z67790
2322 672 91005
2322 672 91029
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150
200
250

Fig. 5.

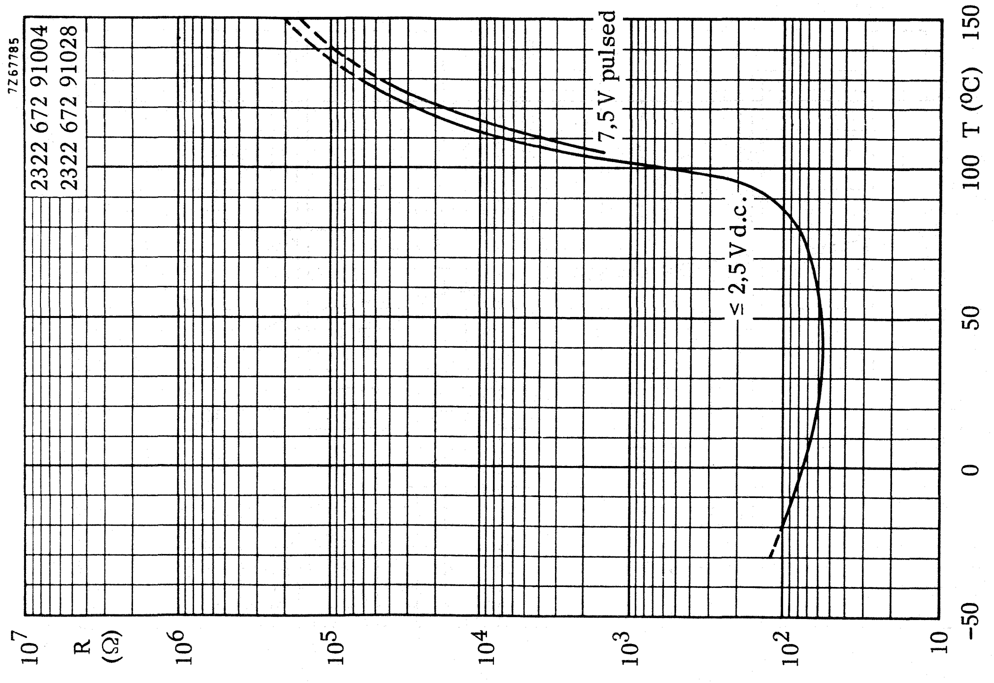

7Z67785
2322 672 91004
2322 672 91028
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
10^7
10^6
10^5
10^4
10^3
10^2
10
T (°C)
−50
0
50
100
150

Fig. 4.

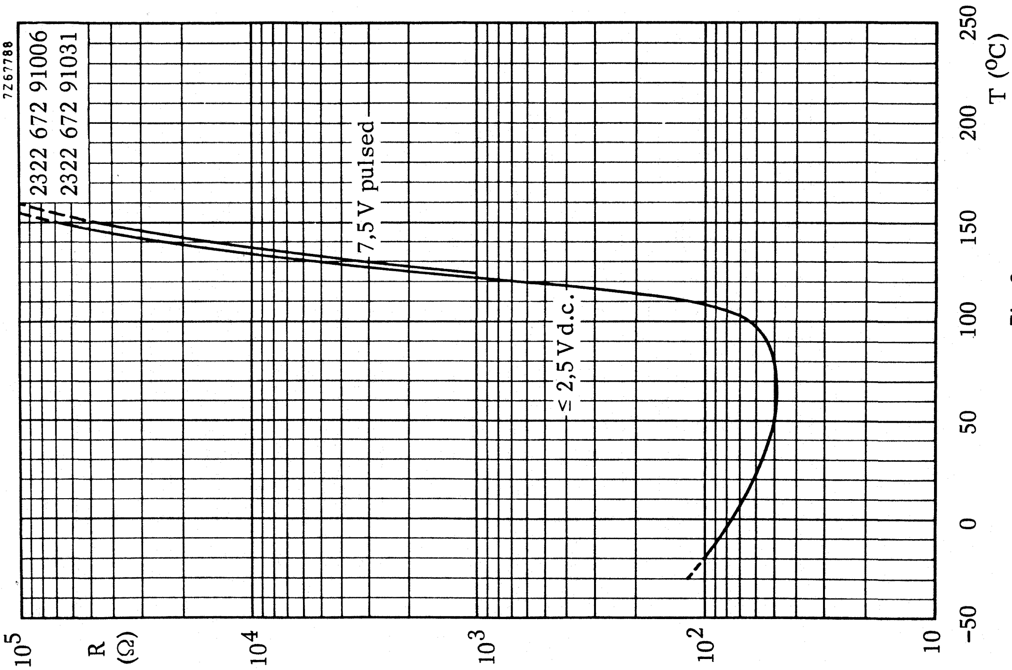

7Z67788
2322 672 91006
2322 672 91031
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 6.

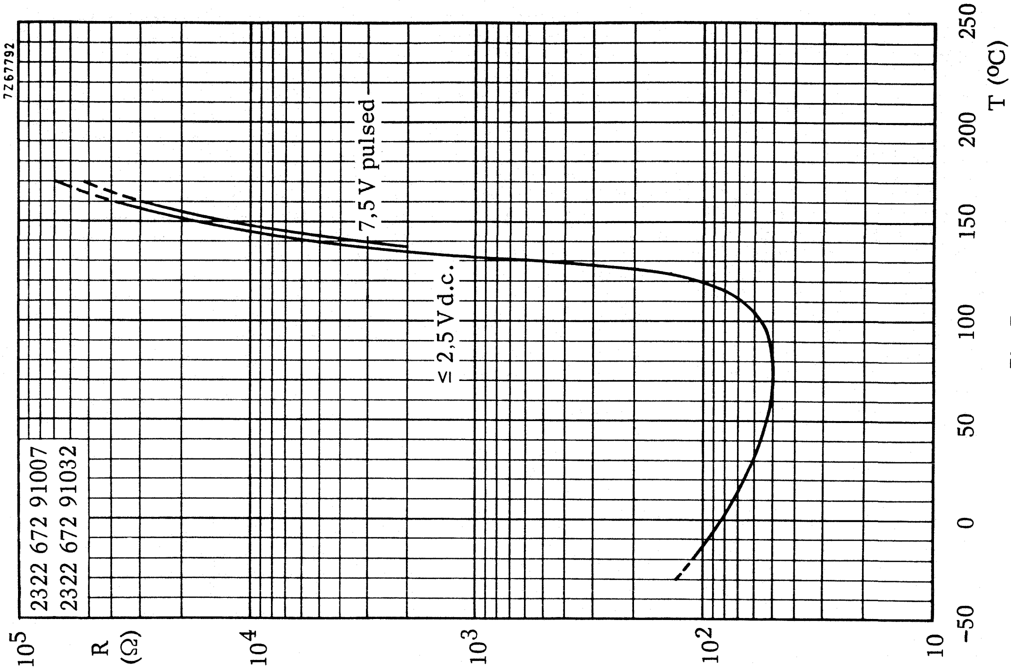

7Z67792
2322 672 91007
2322 672 91032
7,5 V pulsed
≤ 2,5 V d.c.
R
(Ω)
10^5
10^4
10^3
10^2
10
−50
0
50
100
150
200
250
T (°C)

Fig. 7.

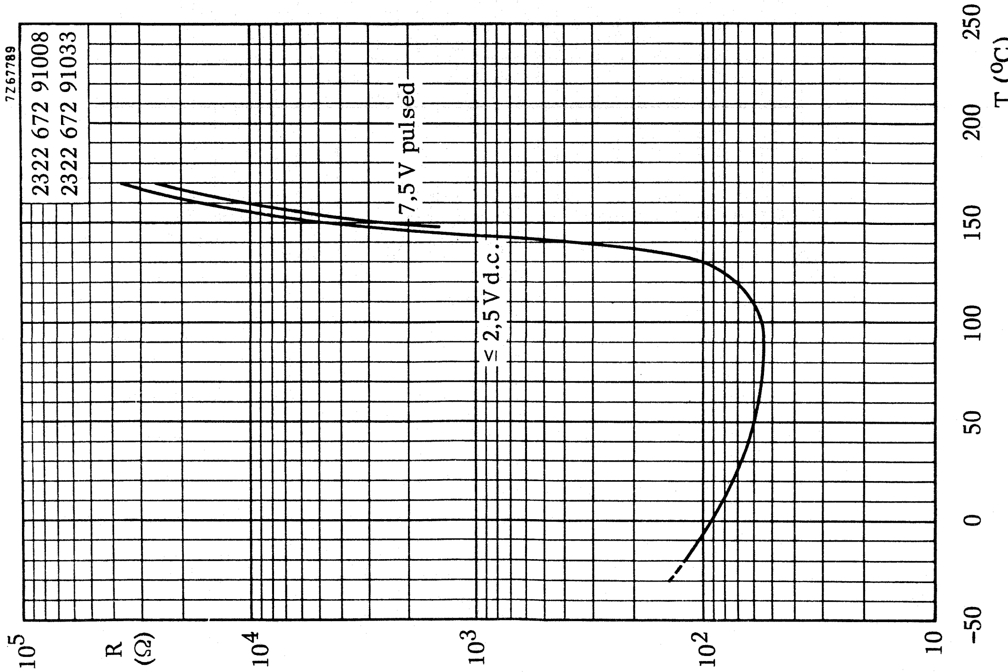

7Z67789
2322 672 91008
2322 672 91033
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
T (°C)

Fig. 8.

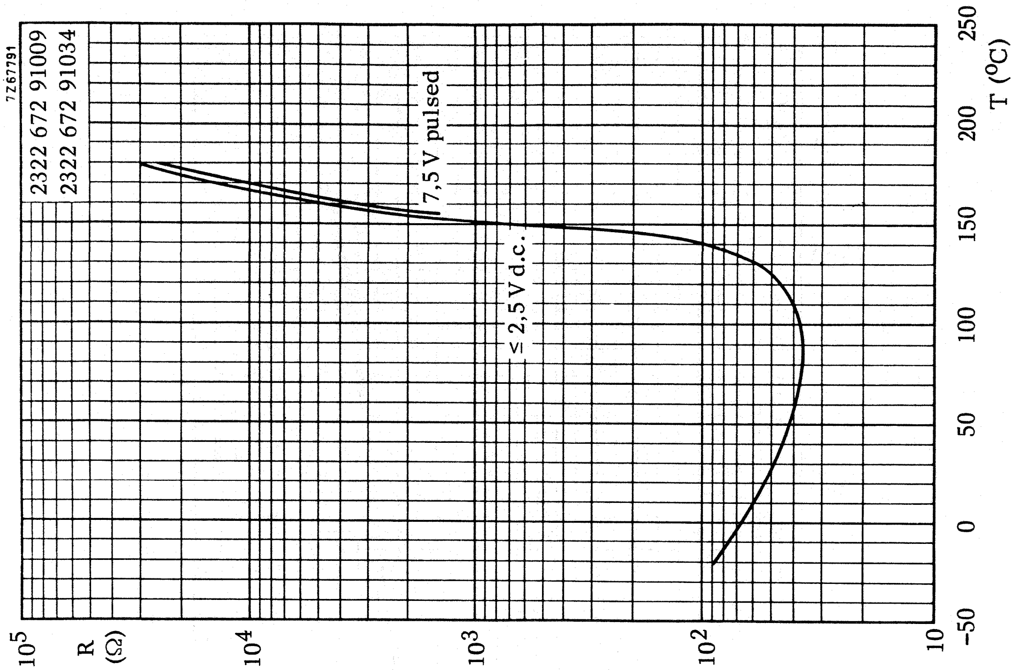

7Z67791
2322 672 91009
2322 672 91034
7,5 V pulsed
≤ 2,5 V d.c.
R (Ω)
T (°C)

Fig. 9.

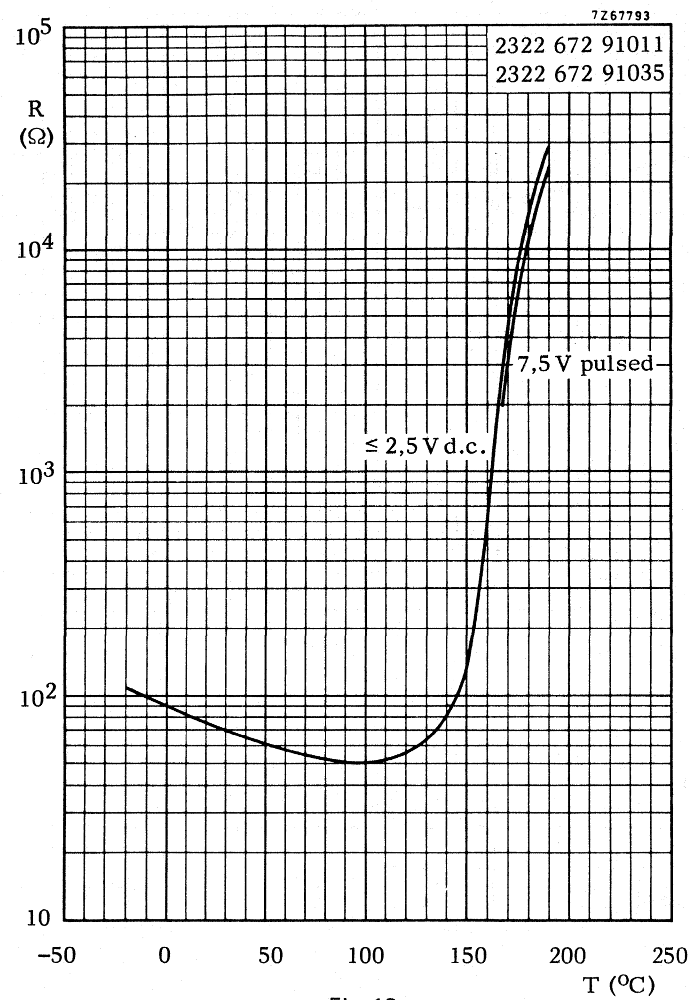

7Z67793
2322 672 91011
2322 672 91035
R
(Ω)
10^5
10^4
10^3
10^2
10
7,5 V pulsed
≤ 2,5 V d.c.
−50
0
50
100
150
200
250
T (°C)

Fig. 10.

PTC THERMISTORS

for motor protection

QUICK REFERENCE DATA

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

APPLICATION

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

DESCRIPTION

The thermistors have a positive temperature coefficient. They consist of a disc with two tinned multi-strand copper wires insulated with PTFE material complying with the requirements of the ministry of aviation specification EL1930.

MECHANICAL DATA

Outlines

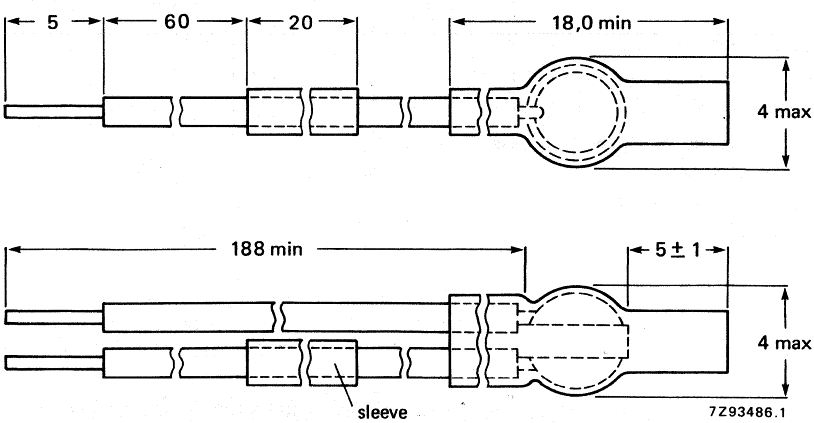


Fig. 1.

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

Mass 1,6 g approximately.

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

PACKAGING

200 thermistors in a cardboard box.

ELECTRICAL DATA

Unless otherwise specified, all measurements are in accordance with IEC Publication 738-1 (1982).

T_{ref} °C (note 1)	T_s °C	temperature coefficient %/K	catalogue number
80	68	18	2322 672 92045
90	75	21	92046
100	88	31	92047
110	99	33	92048
120	113	38	92049
130	123	27	92051
140	130	33	92052
150	137	33	92053

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

Notes

1. T_{ref} is the temperature at which the thermistor has to make the protective system operative.
2. Measuring voltage not exceeding 1,5 V (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).

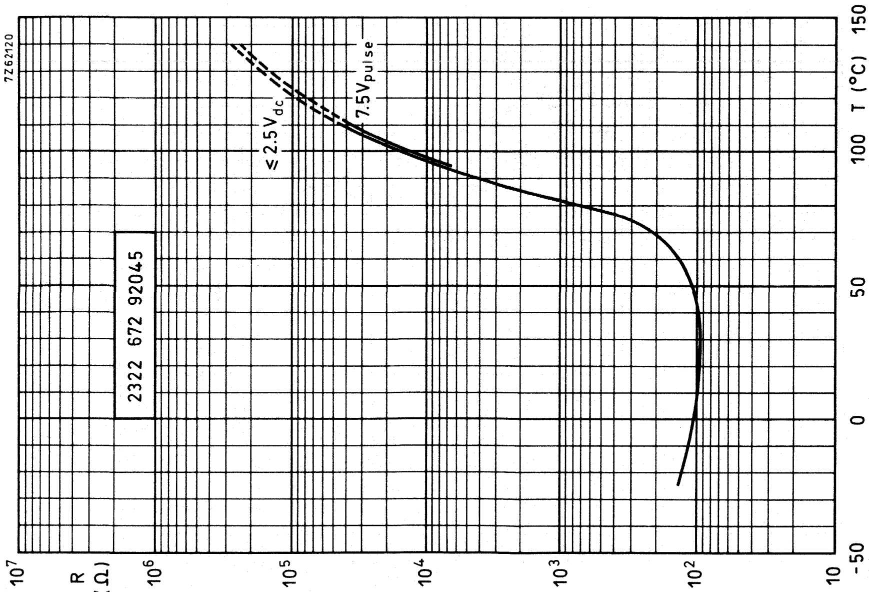


Fig. 2.

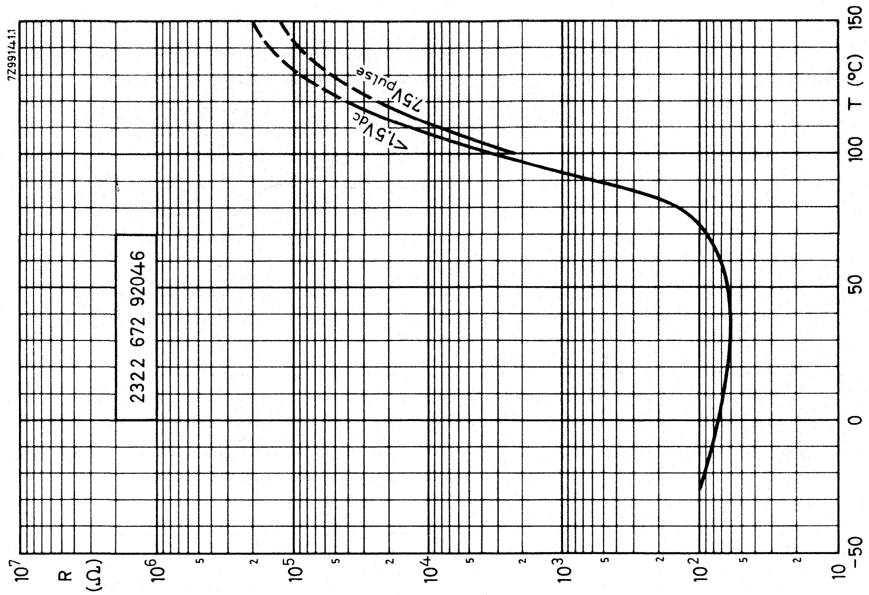


Fig. 3.

Typical resistance/temperature characteristics.

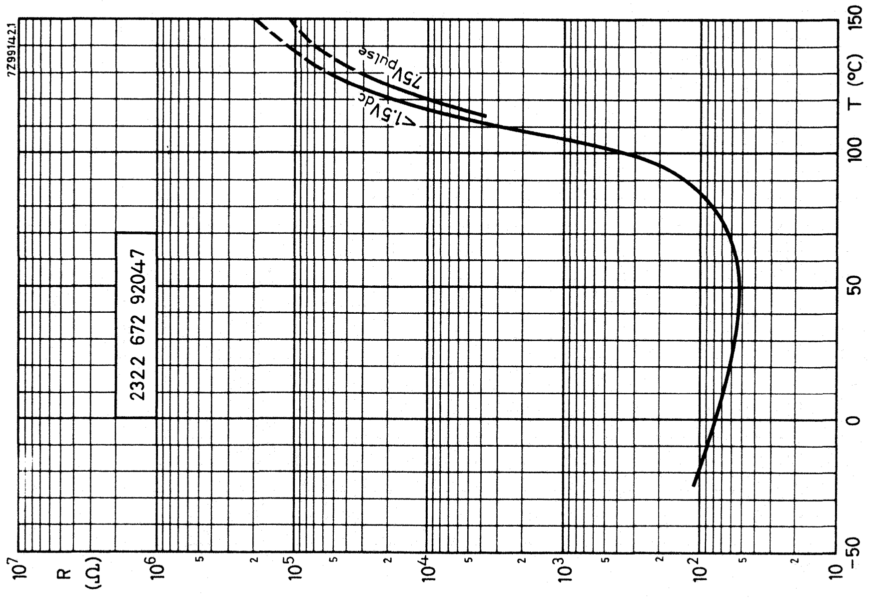


Fig. 4.

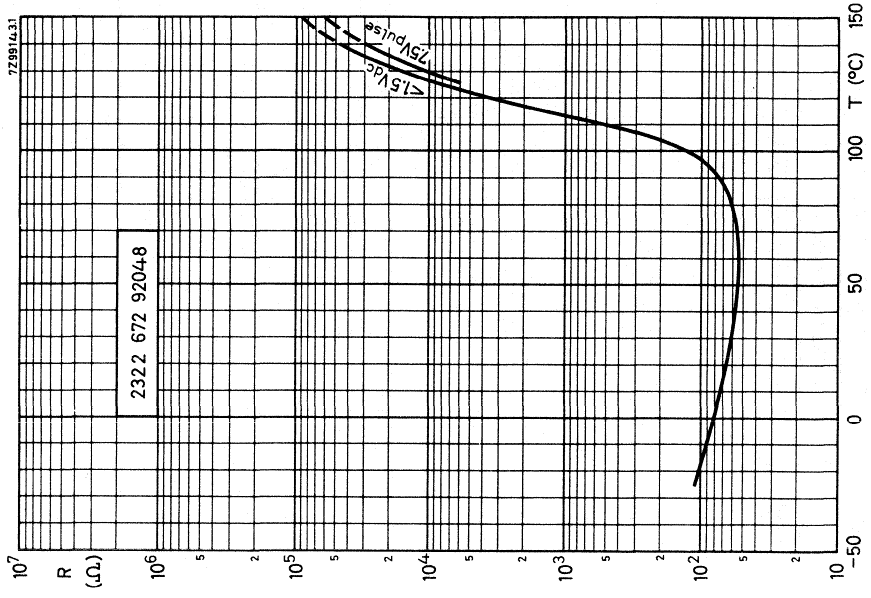


Fig. 5.

Typical resistance/temperature characteristics.

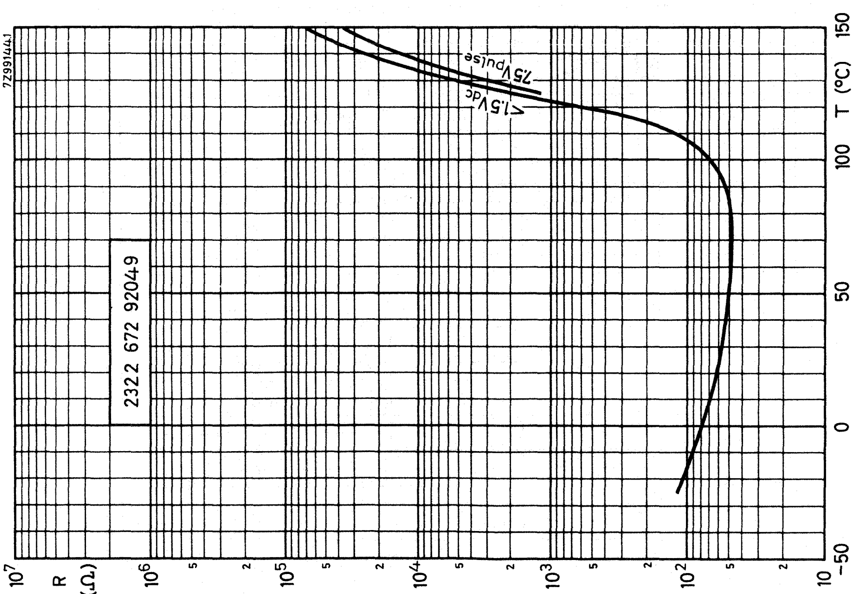


Fig. 6.

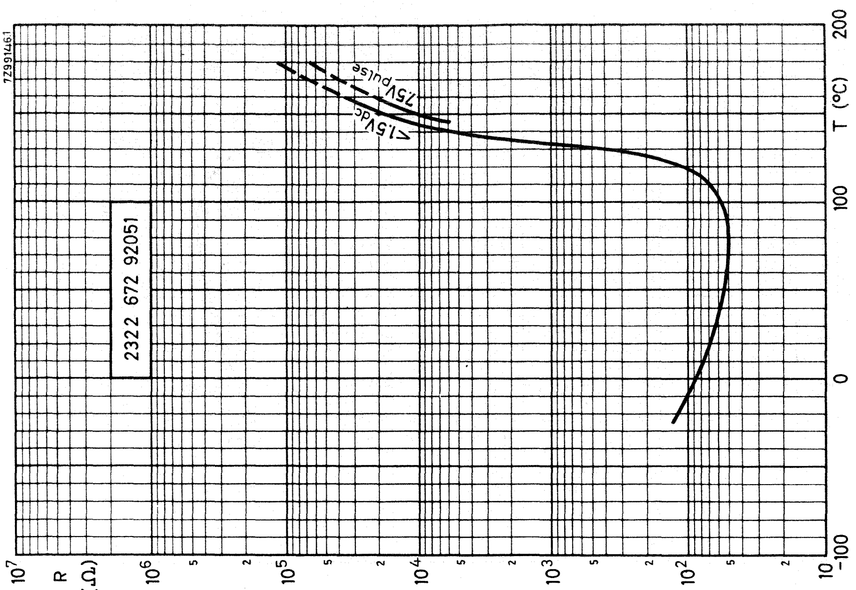


Fig. 7.

Typical resistance/temperature characteristics.

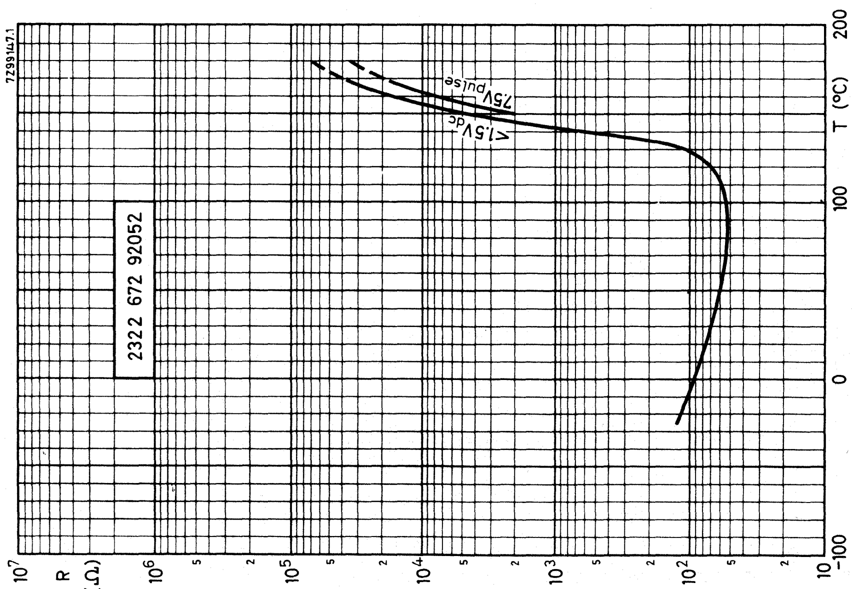


Fig. 8.

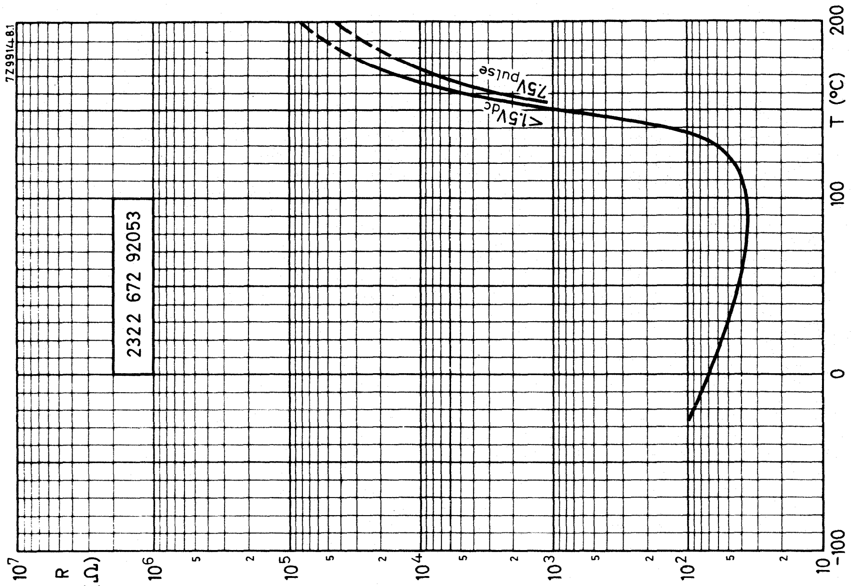


Fig. 9.

Typical resistance/temperature characteristics.

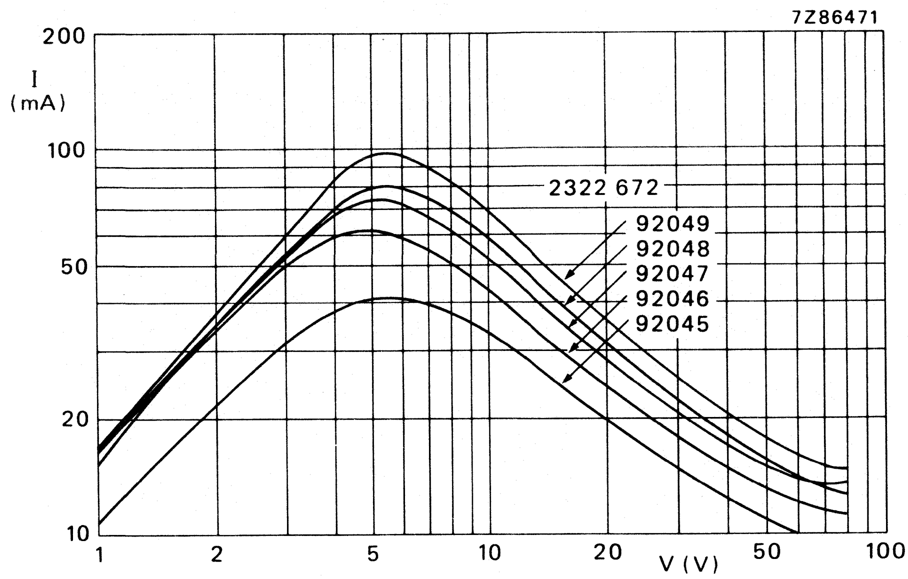


Fig. 10.

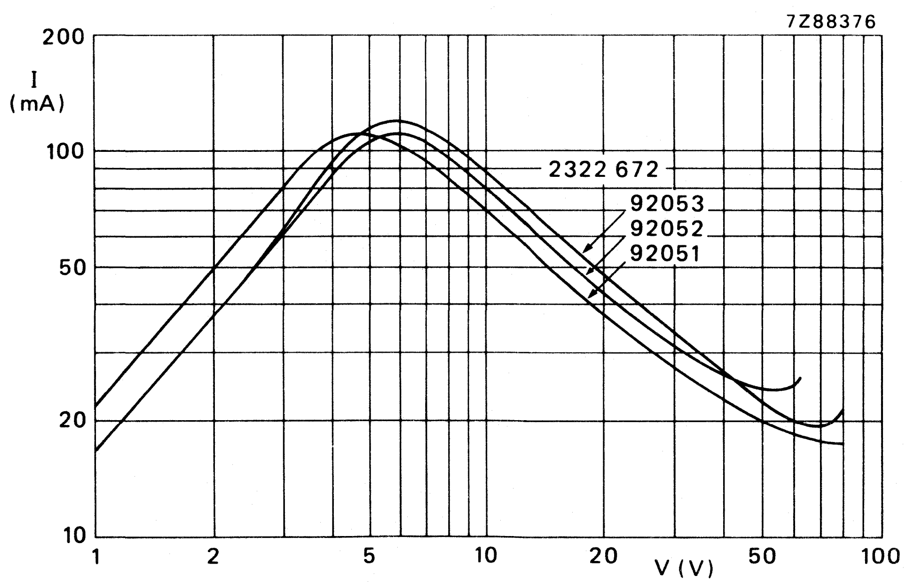


Fig. 11.

Typical voltage/current characteristics.

PTC THERMISTOR

QUICK REFERENCE DATA

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

APPLICATION

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

DESCRIPTION

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

MECHANICAL DATA

Outlines

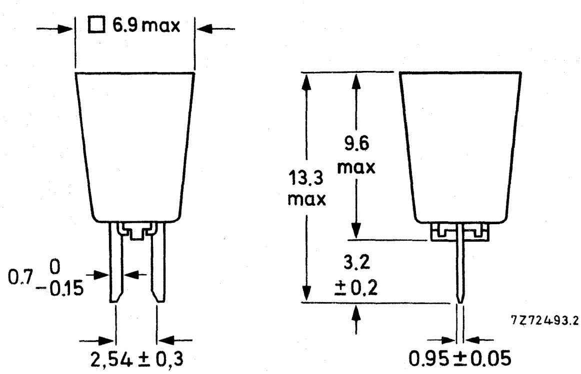


Fig. 1 Component outline

PACKAGING

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

Marking

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

Mass 0,4 g approximately

Mounting to be soldered onto a printed-wiring board

Robustness of terminations

Tensile strength 10 N

Soldering

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

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

Impact

Free fall 1000 mm

Inflammability uninflammable

ELECTRICAL DATA

The values without further indication are approximate values.

Resistance	
at +25 °C	115 ± 25 Ω
at +97 °C	max. 600 Ω
at +155 °C, V_{pulse} = 33 V	min. 15 000 Ω
Switch temperature	+97 °C
Temperature coefficient	min. +10%/K
Operating temperature range	
at zero power	−25 to +155 °C
at maximum voltage	+5 to +55 °C
Maximum voltage (DC)	33 V
Dissipation factor	3,9 mW/K
Thermal time constant	12 s

Maximum dielectric withstanding voltage (RMS) between terminals and capsule	500 V
Insulation resistance between terminals and capsule at 100 V (DC)	min. 10 MΩ

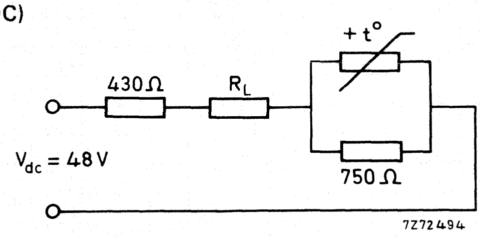
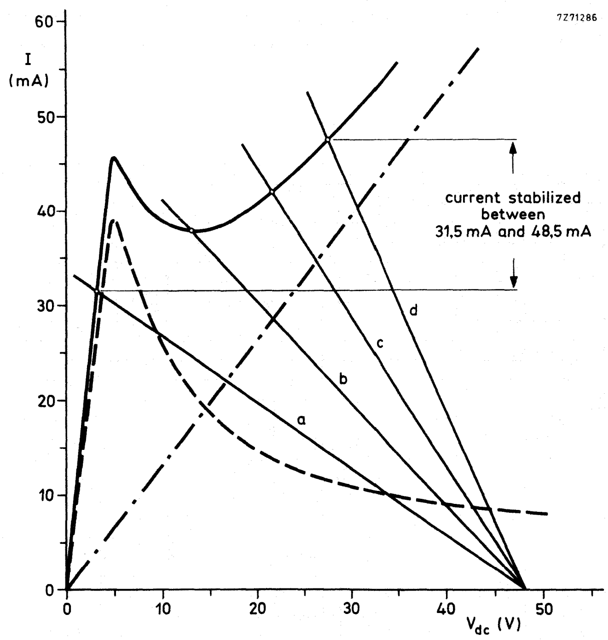


Fig. 2 Line resistance (R_L) compensation.

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



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

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

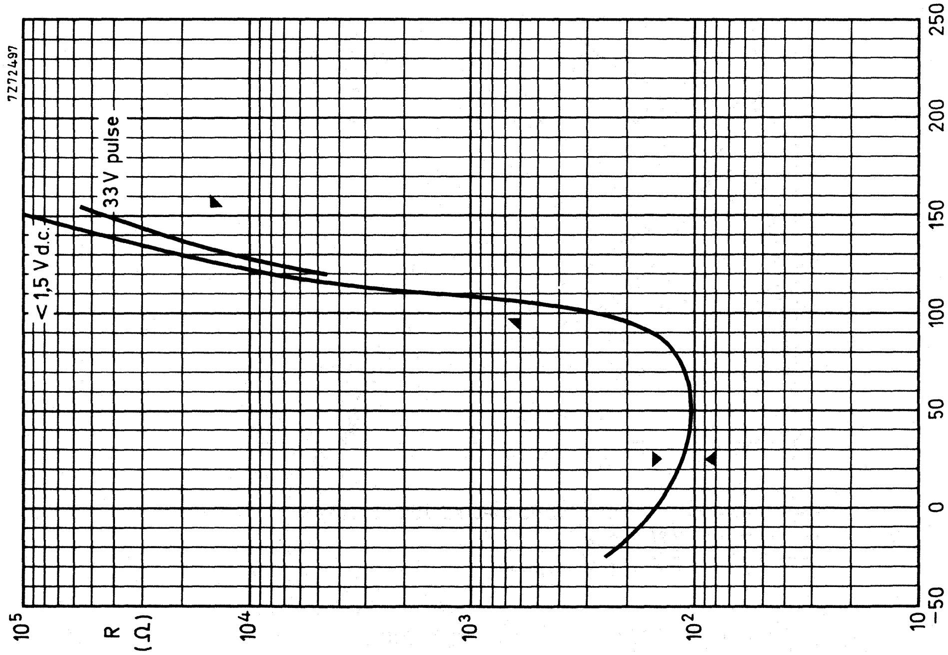


Fig. 4 Typical resistance/temperature characteristics.

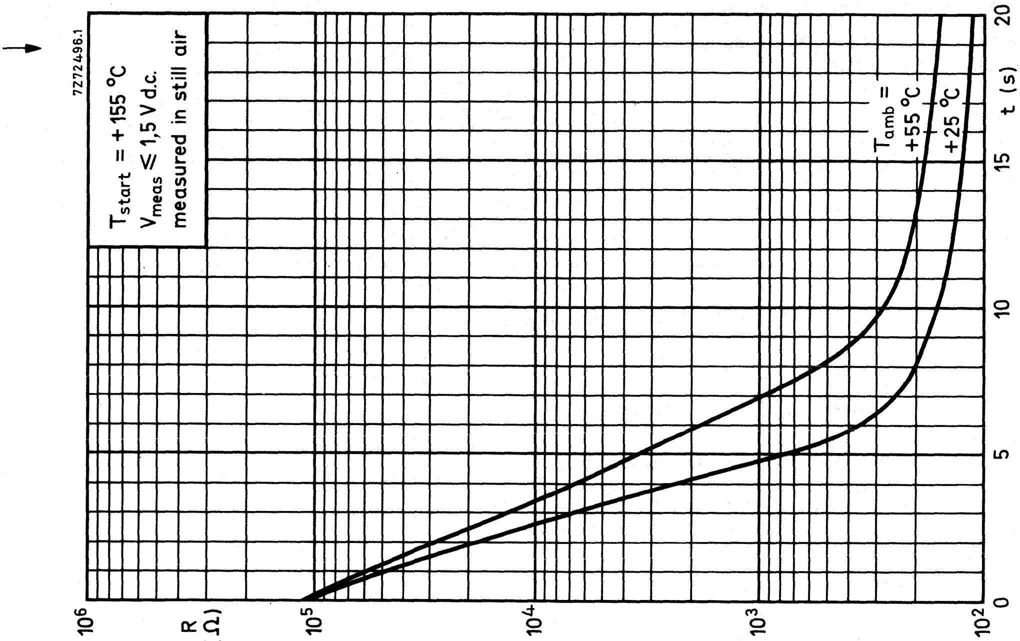


Fig. 5 Typical resistance/time (cooling) characteristics.

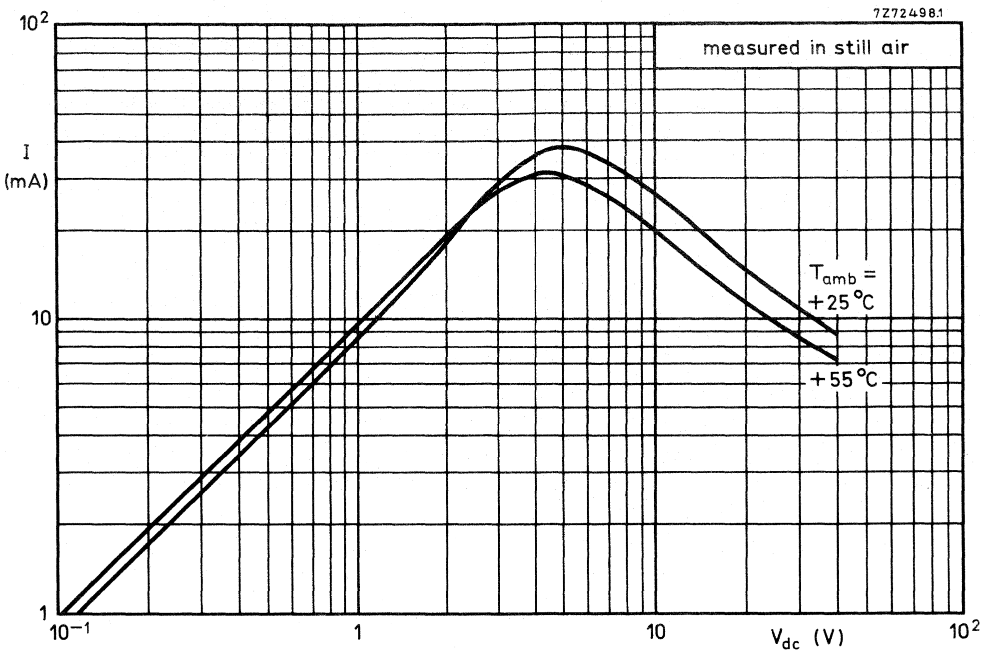


Fig. 6 Typical voltage/current characteristics.

Note:

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

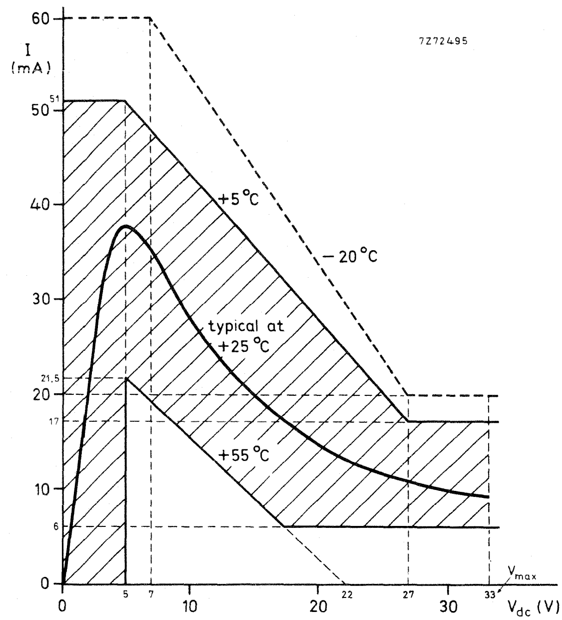


Fig. 7 Area of current/voltage characteristics.

VARISTORS (VDR)

INTRODUCTION

Varistors provide reliable and economical protection against high voltage transients and surges which may be produced, for example, by lightning, switching or electrical noise on AC or DC power lines. They have the advantage over transient suppressor diodes in as much as they can absorb much higher transient energies and can suppress positive and negative transients.

When a transient occurs, the varistor resistance changes from a very high standby value to a very low conducting value. The transient is thus absorbed and clamped to a safe level, protecting sensitive circuit components.

The main features of our varistor range are:

- wide voltage range selection - from 14 V to 550 V RMS. This allows easy selection of the correct component for the specific application
- high energy absorption capability with respect to size of component
- response times of less than 20 ns, clamping the transient the instant it occurs
- low standby power - virtually no current is used in the standby condition
- low capacitance values, making the varistors suitable for the protection of digital switching circuitry
- high body insulation - an ochre coating provides protection up to 2500 V, preventing short circuits to adjacent components or tracks
- available on tape with accurately defined dimensional tolerances, making the varistors ideal for automatic insertion
- approved to Underwriter Laboratory (UL) E-98144 Vol. 1, Sec. 1, and manufactured using UL approved flame retardent materials
- completely non flammable, in accordance with IEC, even under severe loading conditions
- non porous lacquer making the varistors safe for use in humid or toxic evironments. The lacquer is also resistant to cleaning solvents in accordance with IEC 68-2-45
- CECC qualification has been granted for the current range of varistors in production.

VARISTOR MANUFACTURING PROCESS

In order to guarantee top performance and maximum reliability, close in line control is maintained over the automated manufacturing techniques. Figure 1 shows each step of the manufacturing process, clearly indicating the emphasis placed on in line control.

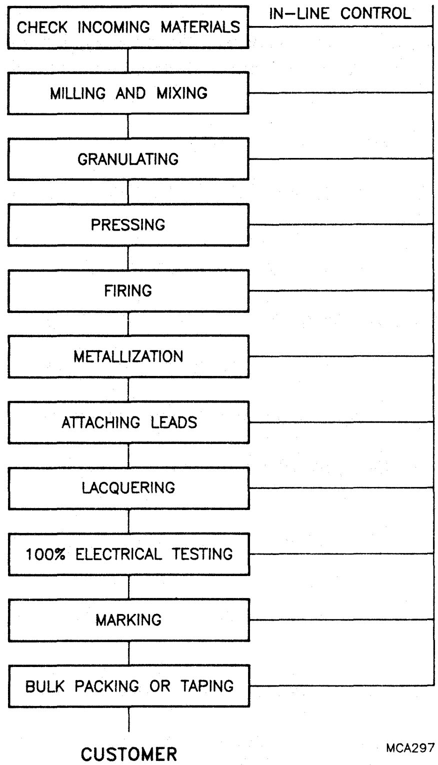


Fig.1 Manufacturing process flow chart.

Each major step in the manufacturing process shown in Fig.1 is described in the following paragraphs:

- **Milling and mixing**
  Incoming materials are checked, weighed, milled and mixed for several hours to make a homogeneous mixture.

- **Granulation**
  A binder is added to produce larger granules for processing.

- **Pressing**
  The surface area and thickness of the disc help to determine the final electrical characteristics of the varistor, therefore pressing is a very important stage in the manufacturing process. The granulated powder is fed into dies and formed into discs using a high speed rotary press.

- **Firing**
  The pressed products are first pre-fired to burn out the binder. They are then fired for a controlled period and temperature until the required electrical characteristics are obtained. Regular visual and electrical checks are made on the fired batch.

- **Metallization**
  The fired ceramic discs are metallized on both faces to produce good electrical contacts. Metallization is achieved by evaporation in a vacuum. Visual checks are made regularly and a solderability test is carried out in each production batch.

- **Attaching leads**
  Leads are automatically soldered to the metallized faces and regular tensile strength tests are made. Three types of lead configuration are available; one with straight leads, one with straight leads with flange, and one with kinked leads.

- **Lacquering**
  The components are coated by immersing them in a special non flammable ochre epoxy lacquer. Two coats are applied and the lacquer is cured. Regular tests to check the coating thickness are made.

- **100% electrical testing**
  The voltage of each component is checked, normally at 1 mA, but any other current may be specified. Any rejects are automatically separated for further evaluation.

- **Marking**
  All components are laser marked.

Varistors are manufactured from a non-homogeneous material, giving a rectifying action at the contact points of two particles. Many series and parallel connections determine the voltage rating and the current capability of the varistor.

Figure 2 shows the structure of a varistor.

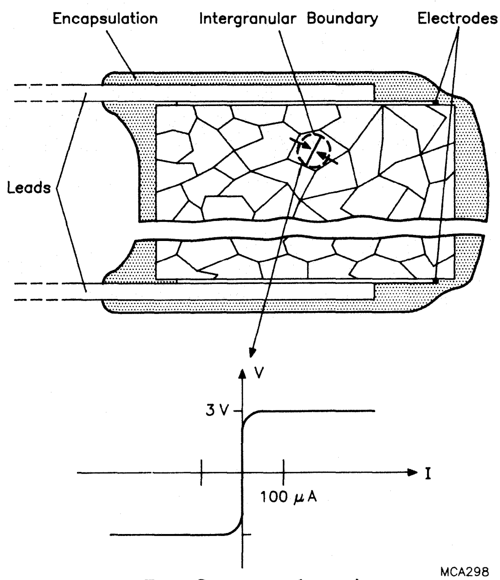


Fig.2 Structure of a varistor.

QUALITY

Approvals

- CECC 42 201-001 (for 30 - 550 V ranges)
- UL E98144
- VDE 53 138 E (for 60 - 460 V ranges)

The term 'QUALITY ASSESSMENT' is defined as the continuous surveillance by the manufacturer of a product to ensure that it conforms to the requirements of the specification to which it was made.

- **Product and process release**
  Recognized reliability criteria are designed into each new product and process from the beginning. Evaluation goes far beyond target specifications and heavy emphasis is placed upon reliability. Before production release, new varistors must successfully complete an extended series of life tests under extreme conditions.

- **Monitoring incoming materials**
  Apart from carrying out physical and chemical checks on incoming raw materials, a very close liaison with materials suppliers is maintained. Incoming inspection and production results are gradually fed back to them, so ensuring that they also maintain the highest quality standards.

- **In-line control**
  The manufacturing centre operates in accordance with the requirements of CECC 42 000 and IEC 40 (Secretariat) 538. Each operator is actively engaged in quality checking. In addition, in-line inspectors make daily spot checks on process and product quality, the results of which are fed into the production process.

- **Final inspection and test (100%)**
  At the end of production, each varistor is inspected and tested prior to packing.

- **Lot testing**
  Before any lot is released, it undergoes a series of special lot tests under the supervision of the Quality Department.

- **Periodic sample testing**
  Component samples are periodically sent to the Quality Laboratory for rigorous climatic and endurance tests to CECC requirements. Data from these tests provide a valuable means of exposing long term trends that might otherwise pass unnoticed. The results of these tests are further used to improve the production process.

- **Field information**
  The most accurate method of assessing quality is monitoring performance of the devices in the field. Customer feedback is actively encouraged and the information is used to study how the components may be further improved. This close relationship with customers is based on mutual trust built up over many years of co-operation.

DEFINITIONS

Maximum continuous voltage
The maximum voltage which may be applied continuously between the terminals of the component. For all types of AC voltages, the voltage level determination is given by the crest voltage x 0.707.

Voltage at 1 mA, or varistor voltage
The voltage across a varistor when a current of 1 mA is passed through the component. The measurement shall be made in as short a time as possible to avoid heat perturbation.

The varistor voltage is essentially a point on the V-I characteristic permitting easy comparison between models and types.

Maximum clamping voltage
The maximum voltage between two terminals when a standard impulse current of rise time 8 µs and decreasing time 20 µs (8/20 µs) is applied through the varistor (in accordance with IEC 60-2, section 6).

The specified current for this measurement is the class current.

Maximum non repetitive surge current
The maximum peak current allowable through the varistor is dependent on pulse shape, duty cycle and number of pulses. In order to characterize the ability of the varistor to withstand impulse currents, it is generally allowed to warrant a 'maximum non repetitive surge current'. This is given for one pulse characterized by the shape of the impulse current of 8/20 µs following IEC 60-2, with such an amplitude that the varistor voltage measured at 1 mA changes by ± 10% maximum.

If more than one impulse is applied when the impulse is of a longer duration, derating curves are applied (see relevant information in the data sheet); these curves guarantee a maximum varistor voltage change of ± 10% by 1 mA measurement.

Maximum energy
During the application of one impulse of current, a certain energy will be dissipated by the varistor. The quantity of dissipated energy is a function of:

- the amplitude of the current
- the voltage corresponding to the peak current
- the rise time of the impulse
- the decrease time of the impulse; most of the energy is dissipated during the time corresponding to between 100% and 50% of the peak current
- the non-linearity of the varistor.

In order to calculate the energy dissipated during a pulse, reference is generally made to a standardized wave of current. The wave prescribed by IEC 60-2 section 6 has a shape which increases from zero to a peak value in a short time, and thereafter decreases to zero either at an approximate exponential rate, or in the manner of a heavily damped sinusoidal curve. This curve is defined by the virtual lead time (t_1) and the virtual time to half value (t_2) as shown in Fig.3.

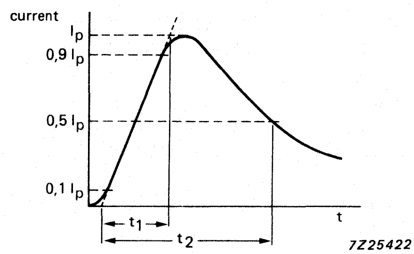


Fig.3 Maximum energy curve.

The calculation of energy during application of such a pulse is given by the formula

$$E = V_P I_P \left(\frac{t_1}{\beta + 2} + \frac{t_2 - t_1}{(\beta + 1)\ln 2} \right)$$

Where:

I_P = peak current

V_P = voltage at peak current

β = given for $I_P = \sqrt{2}$ to I_P

It can be ascertained that the low value of β, corresponds to the low value of dissipated energy for a given peak current and wave shape.

The published maximum energy does not then represent the quality of the varistor, but can be a valuable indication to compare the different series of components having the same varistor voltage. The published maximum energy is valid for a standard impulse of duration 10/1000 μs giving a maximum varistor voltage change of ± 10% at 1 mA.

When more than one pulse is applied, the duty cycle must be so that the rated average dissipation is not exceeded. Values of the rated dissipations are:

0.1 W for series 592
0.25 W for series 593
0.4 W for series 594
0.6 W for series 595.

ELECTRICAL CHARACTERISTICS

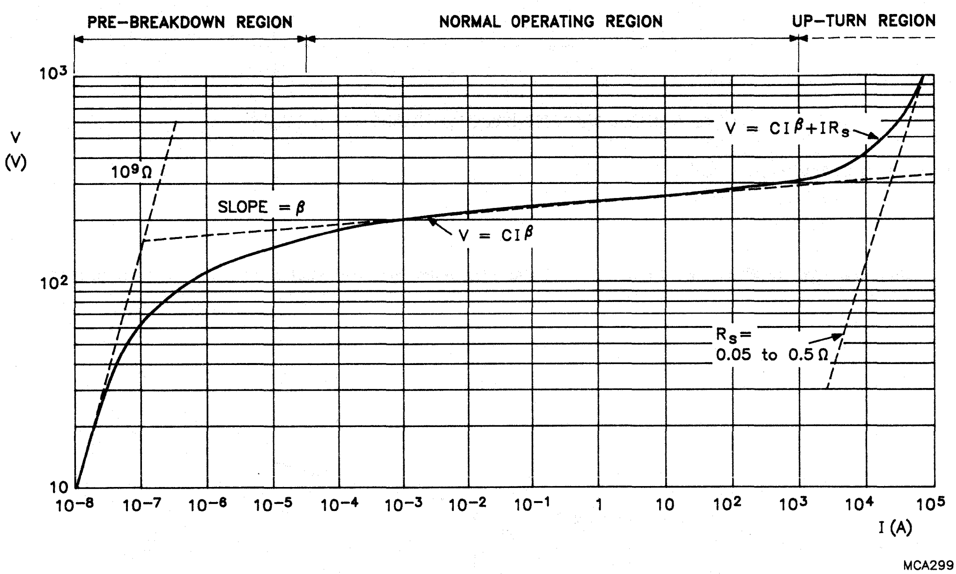
Typical V/I characteristic of a ZnO varistor

The relationship between voltage and current of a varistor can be approximated to:

$$V = CI^{\beta}$$

Where:

V = voltage
C = varistor voltage at 1 Amp
I = actual working current
β = tangent of angle curve deviating from the horizontal



Pre-breakdown region: V = 10.I approximately; highly temperature dependent

Normal operating region: $V = C.I^{\beta}$

Upturn region: $V = C.I^{\beta} + IR_s$

Fig. 4 Typical V/I curve.

Example:
C = 230 V at 1 A
β = 0.035 (ZnO)
I = 0.001 or 100 A

$V = CI^{\beta}$;

for current of 0.001 A; $V = 230.(10^{-3})^{0.035} = 180$ V

for current of 100 A; $V = 230.(10^{2})^{0.035} = 270$ V

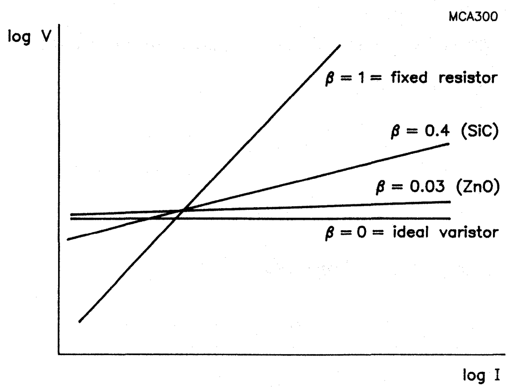


Fig. 5 Varistor characteristics using different β values.

Specification of a varistor curve

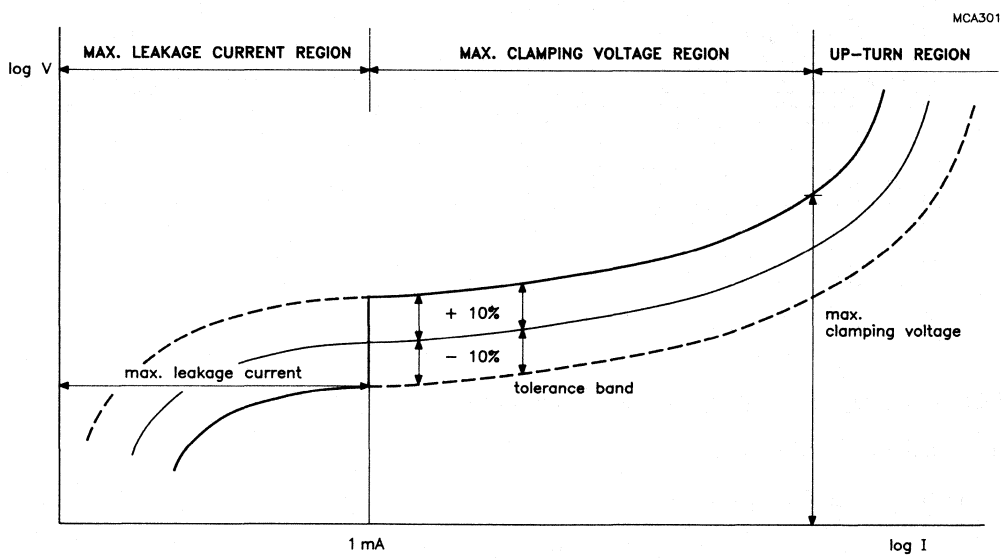


Fig.6 Working points on a varistor curve.

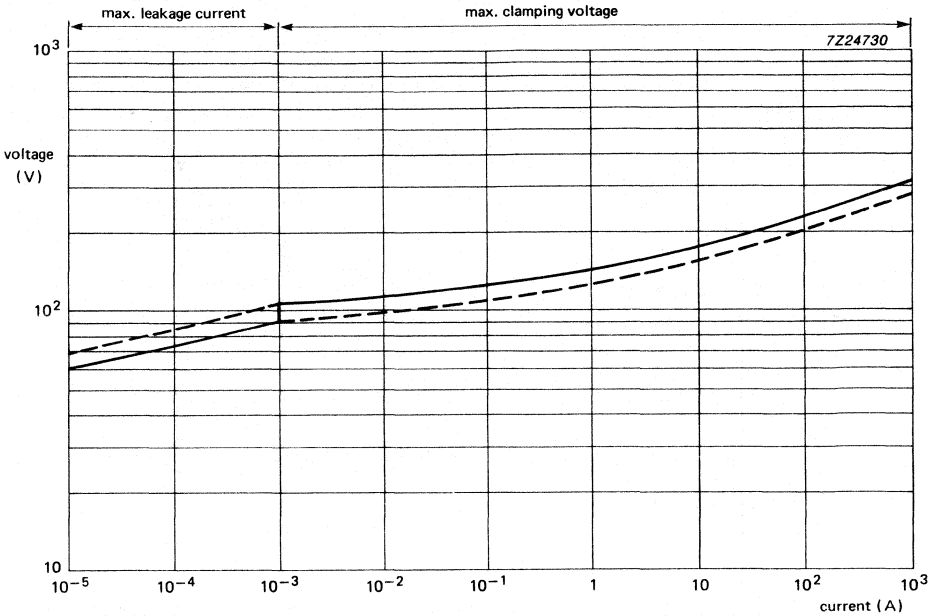


Fig.7 Curve for varistor type 2322 593 .6006

Figure 7 shows the various working points on the varistor curve using the series 2322 593 ..... 60 V type as an example, the values being as follows:

Maximum RMS voltage:	60 V
Maximum DC working voltage:	85 V = 60.√2
Varistor voltage:	100 V ± 10 %
Maximum clamping voltage at 10 A:	165 V
Maximum non repetitive current:	1200 A
Leakage current at 85 V DC:	10^{-5} A to 5.10^{-4}
Transient energy:	10/1000 μs: 5.4 J

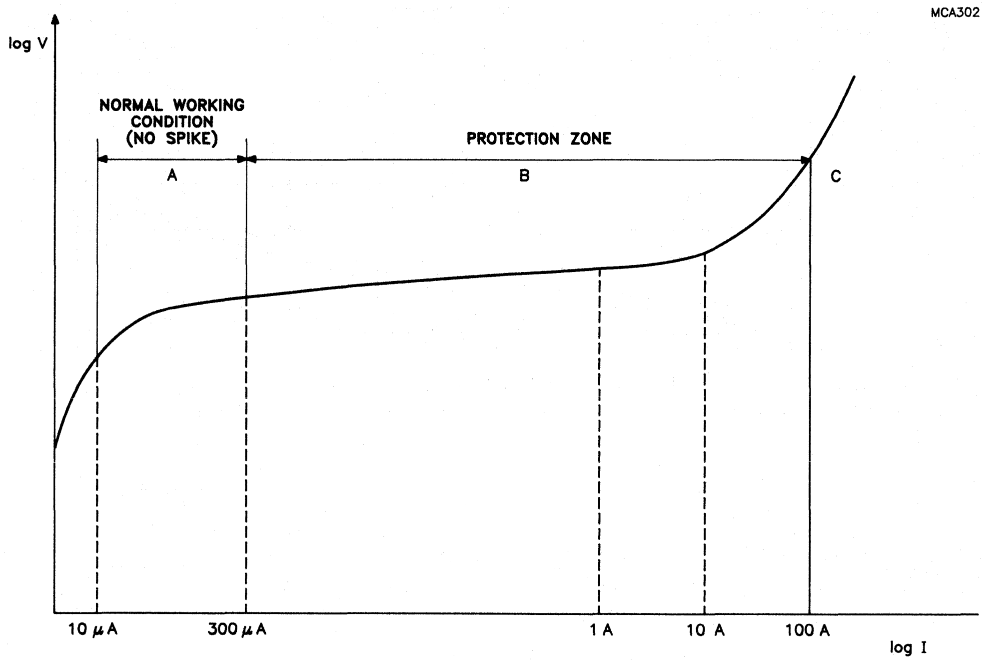


Fig.8 Definitions of the varistor curve.

The points shown on the curve in Fig. 8 are defined as follows:

A: **Normal working zone** - current is kept as low as possible in order to have low dissipation during continuous operation (between 10 - 300 μA)

B: **Maximum clamping voltage** - the maximum voltage for a given (class) current (peak current based upon statistical probability determined by standardization authorities)

C: **Maximum withstanding surge current** - the maximum peak current that the varistor can withstand (only) once in its ifetime.

TRANSIENT VOLTAGE LIMITATION WITH ZN0 VARISTORS

Principles of voltage limitation

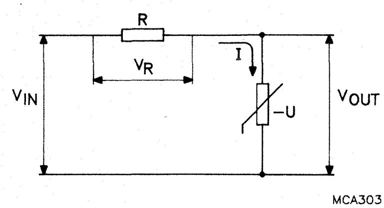


Fig.9 Voltage limitation using a varistor.

In Fig. 9, the supply voltage V_{IN} is derived by the resistance R (e.g. the line resistance) and the Varistor (-U) selected for the application.

$$V_{IN} = V_R + V_{OUT}$$

$$V_{IN} = R_I + CI^{\beta}$$

If the supply voltage varies by an amount of V_{IN} the current variation is I and the supply voltage may be expressed as:

$$(V_{IN} + \Delta V_{IN}) = R(I + \Delta I) + C(I + \Delta I)^{\beta}$$

Given the very small value of β (0.03 to 0.05), it is evident that the modification of CI^{β} will be very small compared to the variation of RI when V_{IN} is increased to $V_{IN} + \Delta V_{IN}$. A large increase of V_{IN} will induce a large increase of V_R and a small increase of V_{OUT}.

Example:

If the varistor is a typical component of the series 2322 592 52716 (C = 520, β = 0.04) and if R = 250 Ω,

for V_{IN} = 315 V (crest voltage of the 220 V supply voltage);

$I = 10^{-5}$ A, $V_R = 2.5 \times 10^{-3}$ V, and V_{OUT} = 315 V.

for V_{IN} = 500 V;

$I = 10^{-1}$ A, V_R = 25 V, and V_{OUT} = 475 V.

for V_{IN} = 1000 V;

I = 1.88 A, V_R = 470 V, and V_{OUT} = 530 V.

Figure 10 shows the influence of different values of series resistors on the varistor.

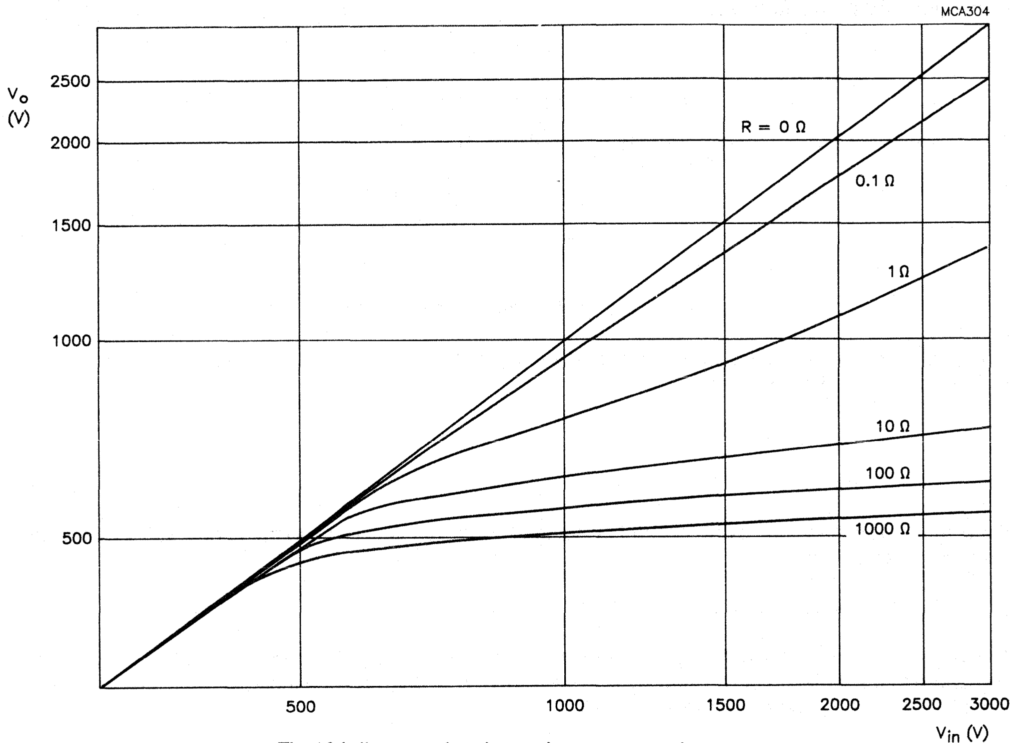


Fig.10 Influence of series resistance on varistor.

By drawing the load line, it is also possible to estimate the variation of the voltages V_R and V_{OUT} when V_{IN} is increased to 500 V or 1000 V. This effect is shown in Figs 11 and 12 respectively.

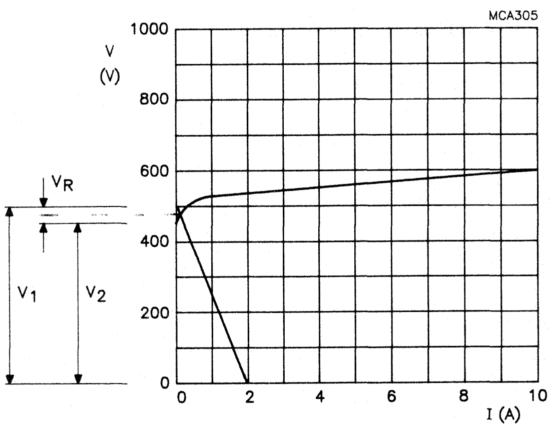


Fig.11 Influence on varistor when V_{IN} is 500 V (R = 250 Ω).

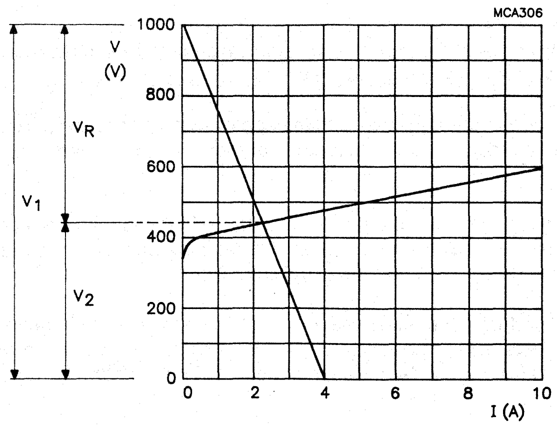


Fig.12 Influence on varistor when V_{IN} is 1000 V (R = 250 Ω).

Equivalent circuit model

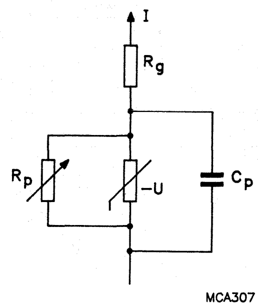


Fig.13 Equivalent circuit model.

A simple equivalent circuit representing a metal oxide varistor as a capacitance in parallel with a voltage dependent resistor is shown in Fig. 13. Cp and Rp are the capacitance and resistance of the intergranular layer respectively; Rg is the Zn0 grain resistance. For low values of applied voltages, Rp behaves as an ohmic loss.

Capacitance

Depending on area and thickness of the device, the capacitance of the varistors increases with the diameter of the disc, and decreases with its thickness.

In DC circuits, the capacitance of the varistors remains approximately constant provided the applied voltage does not rise to the conduction zone, and drops abruptly near the rated maximum continuous DC voltage.

In AC circuits, the capacitance can affect the parallel resistance in the leakage region of the V-I characteristic. The relationship is approximately linear with the frequency and the resulting parallel resistance can be calculated from $1/\omega C$ as for a usual capacitor.

Nevertheless, due to the structural characteristics of the zinc oxide varistors, the capacitance itself decreases slightly with an increase in frequency. This phenomenon is emphasized when the frequency reaches approximately 100 kHz. Figure 14 shows the effect of HF alternating current on the varistor.

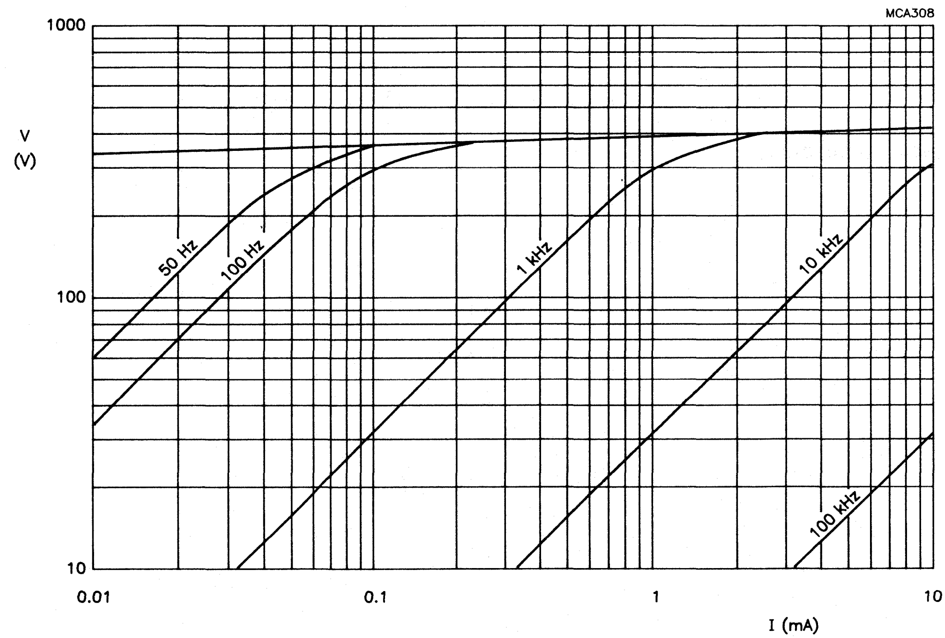


Fig.14 Effect of HF alternating current on varistor, type 2322 595 52516, C = 480 pF.

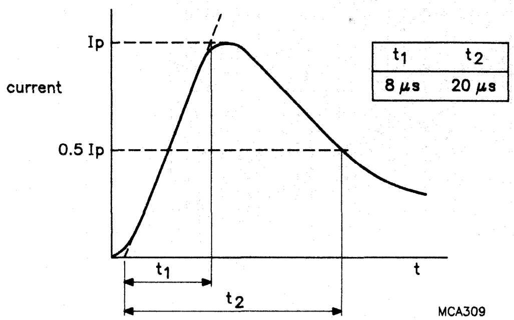
Energy handling

Maximum allowable peak current and maximum allowable energy are standardized using defined pulses.

- peak current (amperes); 8/20 µs - 1 pulse
- energy (joules); 10/1000 µs - 1 pulse

Surge life rating - curves (number of surges allowed as a function of pulsetime and maximum current).

Internationally accepted test pulses



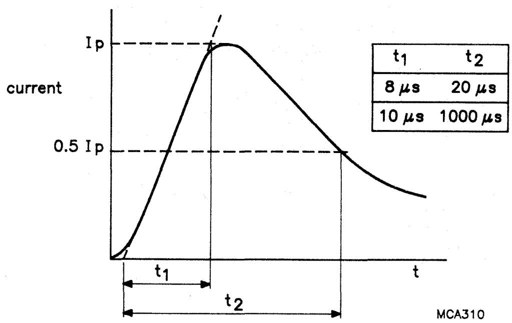
Max. allowable peak current (one time only)

<u>Examples</u>

593 52516 (250V) = 1200 A
593 53006 (30V) = 250 A
595 52516 (250V) = 4500 A
595 53006 (30V) = 1000 A

Fig.15 Standard impulse current following IEC publication 60-2, paragraph 16.1.

Pulse life time rating of 593 60V-type



Energie capability : $E = K.V_p.I_p t_2$

1 pulse 8/20 µs: 1200 A = 1 x 8 J
10 pulses 8/20 µs: 300 A = 10 x 1.45 J
1 pulse 10/1000 µs: 33 A = 1 x 5.4 J
10 pulses 10/1000 µs: 11 A = 10 x 2.5 J

After test: (ΔV/V) 1 mA ≤ 10%

I_p = pulse current
V_p = corresponding clamping voltage

Fig.16 Examples of energy capabilities for different levels of current amplitude or impulse duration.

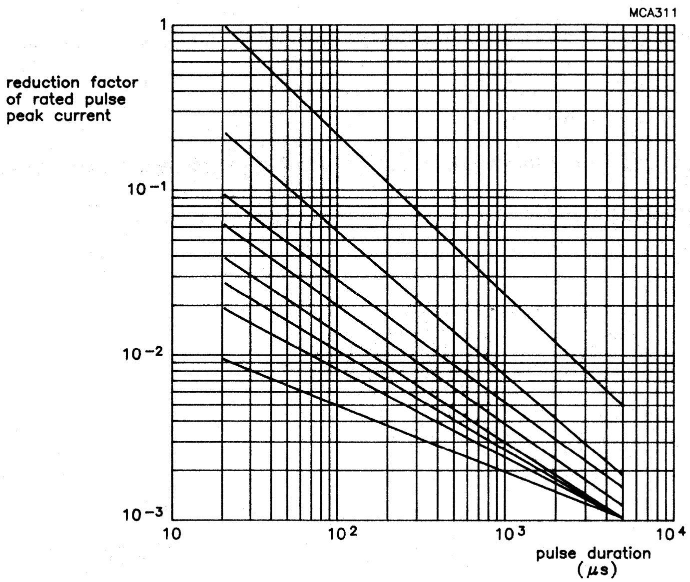
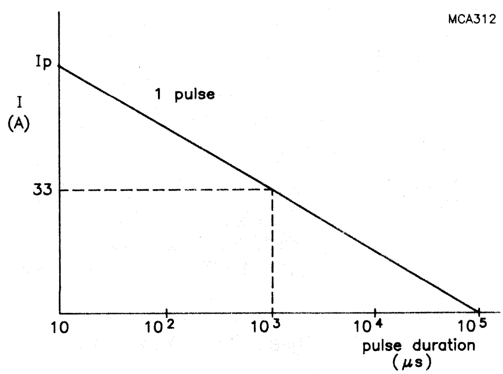


Fig.17 Maximum peak current for various number of pulses as a function of pulse duration.

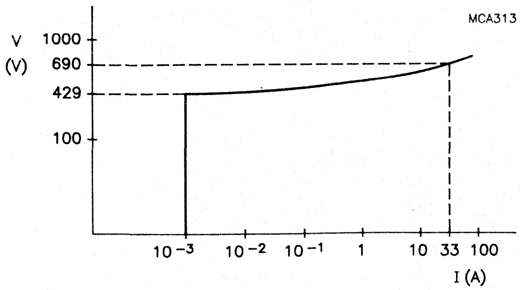


Maximum energy (10 x 1000 μs)

Example

593 52516 (250 V)

Fig. 18 Example of selection of the maximum peak current as a function of pulse duration.



$$E = K \times V_p \times I_p \times t_2$$
$$= 1.4 \times 700 \times 33 \times 10^{-3} = 32 \text{ joules}$$

Fig. 19 Example of calculation of energy for a 2322 593 52516 type, 1 impulse at the maximum peak current (33A) for a duration t_2 = 1000 μs (k = 1.4).

DISSIPATED POWER

DC dissipation

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

$$W = I.V = CI^{\beta+1} \text{ or } KV^{\alpha+1}$$

When the coefficient $\alpha = 30$ ($\beta = 0.033$), the power dissipated by the varistor is proportional to the 31st power of the voltage. A voltage increase of only 2.26% 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, otherwise the permissible rating will be exceeded.

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

AC dissipation

When a sinusoidal alternating voltage is applied to a varistor, the dissipation cannot be calculated from the same formula as in a DC application. The calculation requires an integration of the V.I product.

The instantaneous dissipated power is given by:

$$P_{INST} = V.I = V(K.V^{\alpha}) = K.V^{\alpha+1}$$

In the above equation, the value $V = V_{PEAK}.\sin \omega t$.

During a half cycle, the dissipated power is then given by:

$$P_{RMS} = \frac{1}{\pi} \int_0^{\pi} K.V_{PEAK}^{\alpha+1} \; (\sin \omega t)^{\alpha+1}.dt$$

Since $V_{PEAK} = V_{RMS} \times \sqrt{2}$

$$P_{RMS} = \frac{1}{\pi} .K.V_{RMS}^{\alpha+1}.(\sqrt{2})^{\alpha+1} \int_0^{\pi} \; (\sin \omega t)^{\alpha+1}.dt$$

This integration is not easy to solve because of the exponent $\alpha + 1$ of sin ωt.

It is generally easier to use the quotient of the AC power on the DC power:

$P = P_{AC}/P_{DC}$.

This quotient depends only from the value of α and not more of the K value as shown in the formula:

$$P = \frac{\frac{1}{\pi}.K.V_{RMS}^{\alpha+1}.2^{(\alpha+1)/2} \int_0^{\pi} (\sin \omega t)^{\alpha+1}.dt}{KV^{\alpha+1}}$$

$$P = \frac{1}{\pi}.2^{(\alpha+1)/2} \int_0^{\pi} (\sin \omega t)^{\alpha+1}.dt$$

P has been calculated by successive application of a reduction formula, and is tabulated below:

Table 1 Power ratios

α	P	α	P	α	P	α	P	α	P
1	1.00	11	14.4	21	344	31	9.135	41	255.646
2	1.20	12	19.6	22	477	32	12.776	42	358.778
3	1.50	13	26.8	23	658	33	17.734	43	499.673
4	1.92	14	36.7	24	915	34	24.822	44	701.611
5	2.50	15	50.3	25	1264	35	34.482	45	977.622
6	3.29	16	69.0	26	1763	36	48.301	46	1373.365
7	4.375	17	95.0	27	2439	37	67.149	47	1914.510
8	5.85	18	131	28	3404	38	94.126	48	2690.675
9	7.875	19	180	29	4715	39	130.941	49	3752.439
10	10.64	20	249	30	6587	40	183.660	50	5275.834

Temperature coefficient

In the 'leakage current' region of the V/I characteristic, the normal equation $V = CI^{\beta}$ of the varistor becomes less applicable.

This is due to a parallel resistance which shows a very important temperature coefficient, created by thermal conduction. This temperature coefficient decreases when the current density increases. Then, the temperature coefficient at 1 mA is higher for a large varistor than for a small varistor.

This phenomena induces an increase in leakage current when the varistor is used at high temperature. The relationship between the temperature can be expressed by:

$I = I_0.e^{KT}$

where:

I_0 is the limiting current at 0 ° Kelvin

K is a constant including the band gap energy of the zinc oxide and the Boltzmann's constant.

Practically, the maximum temperature coefficient is guaranteed on the voltage for a current of 1 mA, in % by K.

SURGE PROTECTION

Varistors provide protection against surges which may be generated in the following ways:

- **Electromagnetic energy**

Atmospheric - lightning

Switching of inductive loads - relays
pumps
actuators
spot welders
thermostats
fluorescent chokes
discharge lamps
motors
transformers
air conditioning units
fuses.

- **Electrostatic discharges**

For example, discharges caused by synthetic carpets (approximately 50 kV).

Source of transient

The energy dissipated by switching of an inductive load is completely transferred in the capacitance of the coil which is generally very low.

$E = 1/2\ (LI^2) = 1/2\ (CV^2)$

Examples, using the following values

Mains voltage = 220 V RMS (allowable peak voltage = 340 V)
Line inductance = 20 µH (2.10^{-5} H)
Line capacitance = 1 µF (10^{-6} F)
Line resistance = 0.34 Ω

1. In the event of a short circuit:

   Load current $I_L = V/R = 340\ V/0.34\ \Omega = 1000\ A$

   Energy stored $E = 1/2\ (2 \times 10^{-5})\ .\ 10^6 = 10$ Joules (W.s)

2. In the event of a fuse going open circuit:

   The energy goes from inductance L towards line capacitance

   $V_C = \sqrt{2E/C} = 2 \times 10/10^{-6} = 20 \times 10^6 = 4472\ V$

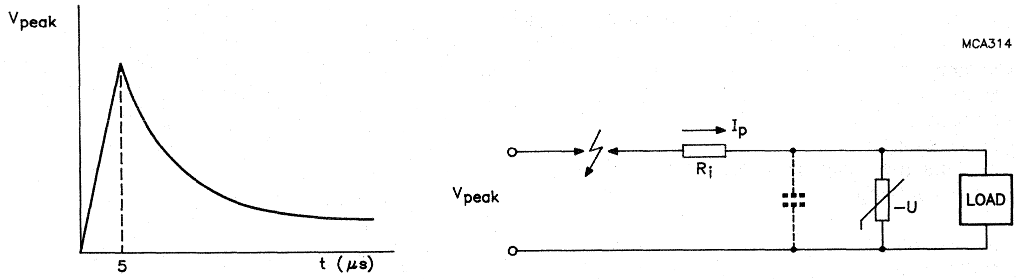


Fig.20 Source of transient.

The line impedance becomes high when the fuse goes open circuit (resistance against high voltage peak in a very short time).

$R_i = 1/\omega C = 1/2\ (\pi f C)$

Since the rise time of the pulse is 5 μs, the frequency f = 0.2 MHz.

$R_i = 1/6.28 \times 0.2 \ .\ 10^{-6} \times 10^{-8} = 80\ \Omega$

$I_p = 48$ A

$V_{RI} = 80 \times 48 = 3820$ V

$V_{VDR} = 652\ V = V_{LOAD}$

VARISTOR APPLICATIONS

Varistors may be used in many applications, including:

- computers
- timers
- amplifiers
- oscilloscopes
- medical analysis equipment
- street lightning
- tuners
- televisions
- controllers
- industrial power plant
- telecommunications
- automotive
- gas and petrol appliances
- electronic home appliances
- relays
- broadcasting
- traffic facilities
- electromagnetic valves
- railway distribution/vehicles
- agriculture
- power supplies
- line ground (earth protection)
- microwave ovens
- toys, etc.

Application examples

1. For suppression of mains-borne transients in domestic appliances and industrial equipment.

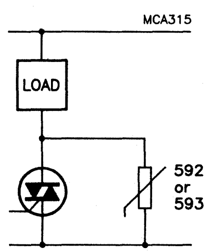


Fig. 21 Suppression via load.

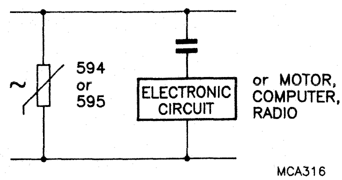


Fig. 22 Suppression directly across mains.

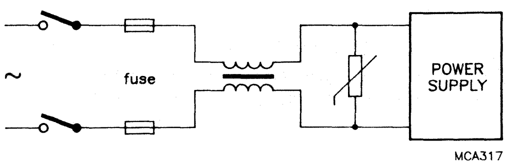


Fig. 23 Switched-mode power supply protection.

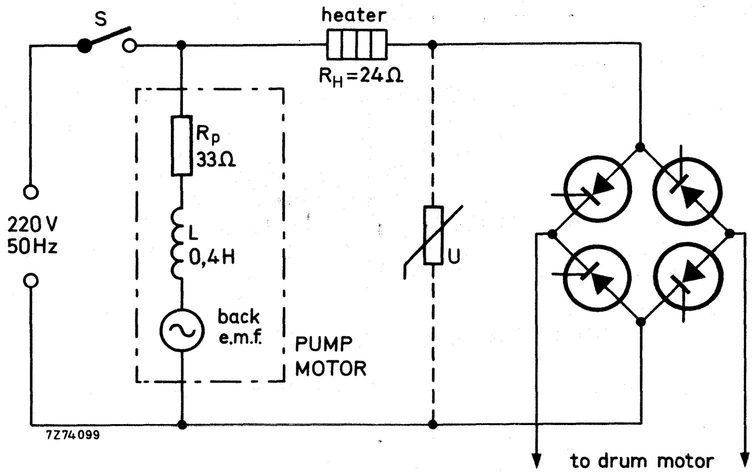


Fig. 24 Protection of a thyristor bridge in a washing machine.

Behaviour of the circuit without varistor 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:

$I^2L/2 = 0.4/2 = 200$ mJ.

Without varistor protection, an initial current of 1 A will flow through the thyristor bridge when S is opened, 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 varistor 2322 593 52516 inserted

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

$$V = C_{MAX}\, I^{\beta} = 600\,V$$

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

The total energy returned to the circuit is 200 mJ. Of this 200 mJ, 15.1 mJ is dissipated in the heater, and 184.3 mJ is dissipated in the varistor. The varistor can withstand more than 10^5 transients containing this amount of energy.

2. For suppression of internally generated spikes in electronic circuits.

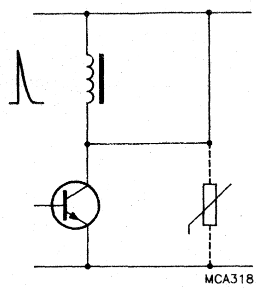


Fig. 25 Varistor used across a transistor or coil in a television circuit.

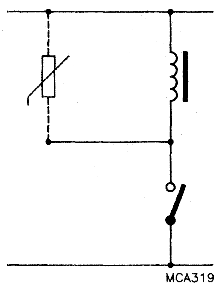


Fig. 26 Varistor used across a switch or coil.

In both examples shown above, type 2322 592 should be used for up to approximately 200 A, and type 2322 593 should be used up to approximately 500 A.

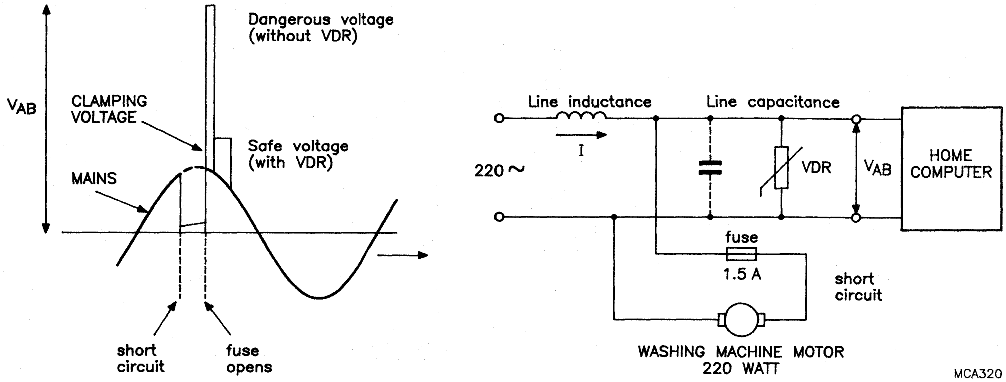


Fig. 27 Influence of a transient on the mains voltage.

SELECTION OF THE CORRECT VARISTOR TYPE

In order to select a Zn0 varistor for a specific application, the following points must first be considered:

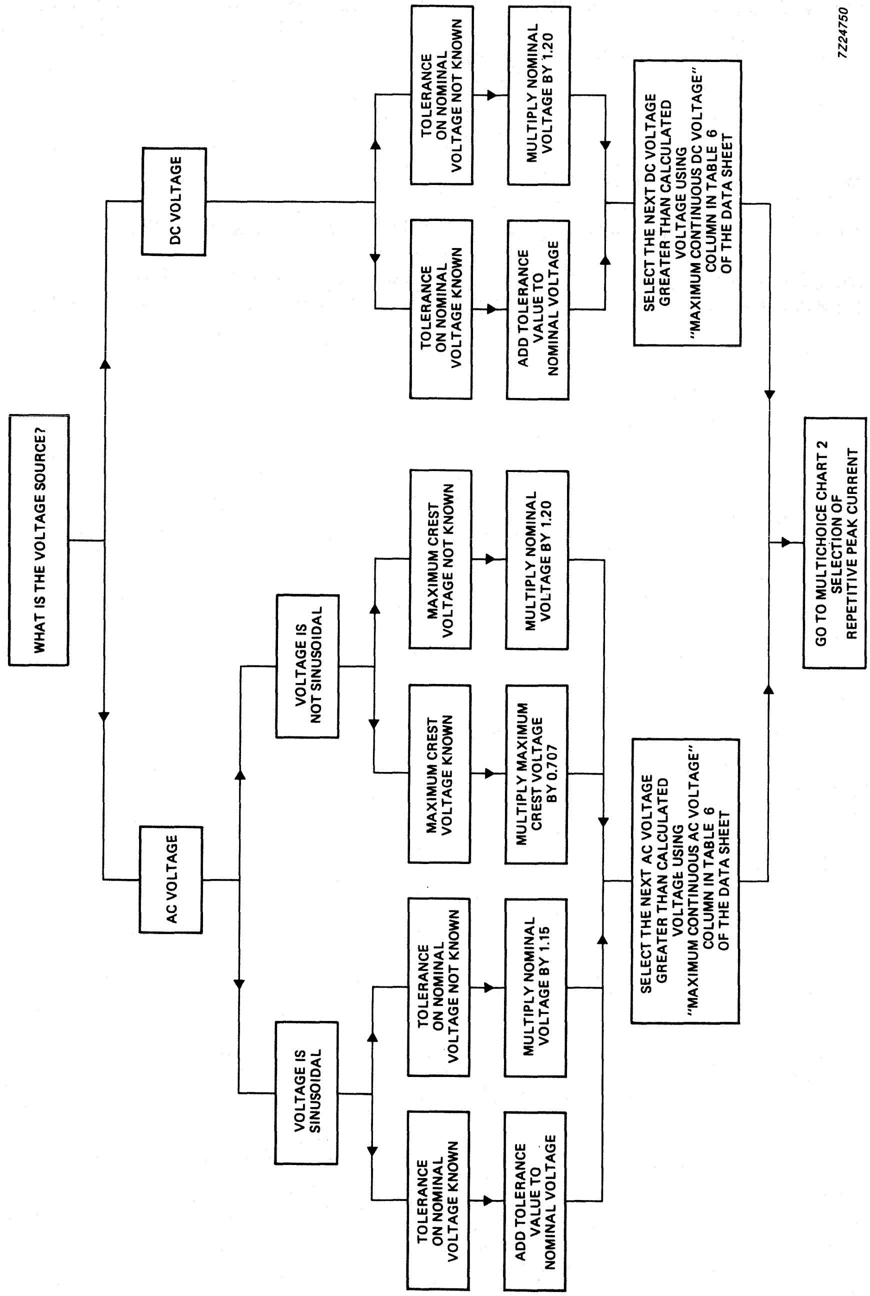
1.The normal operating conditions of the apparatus or system

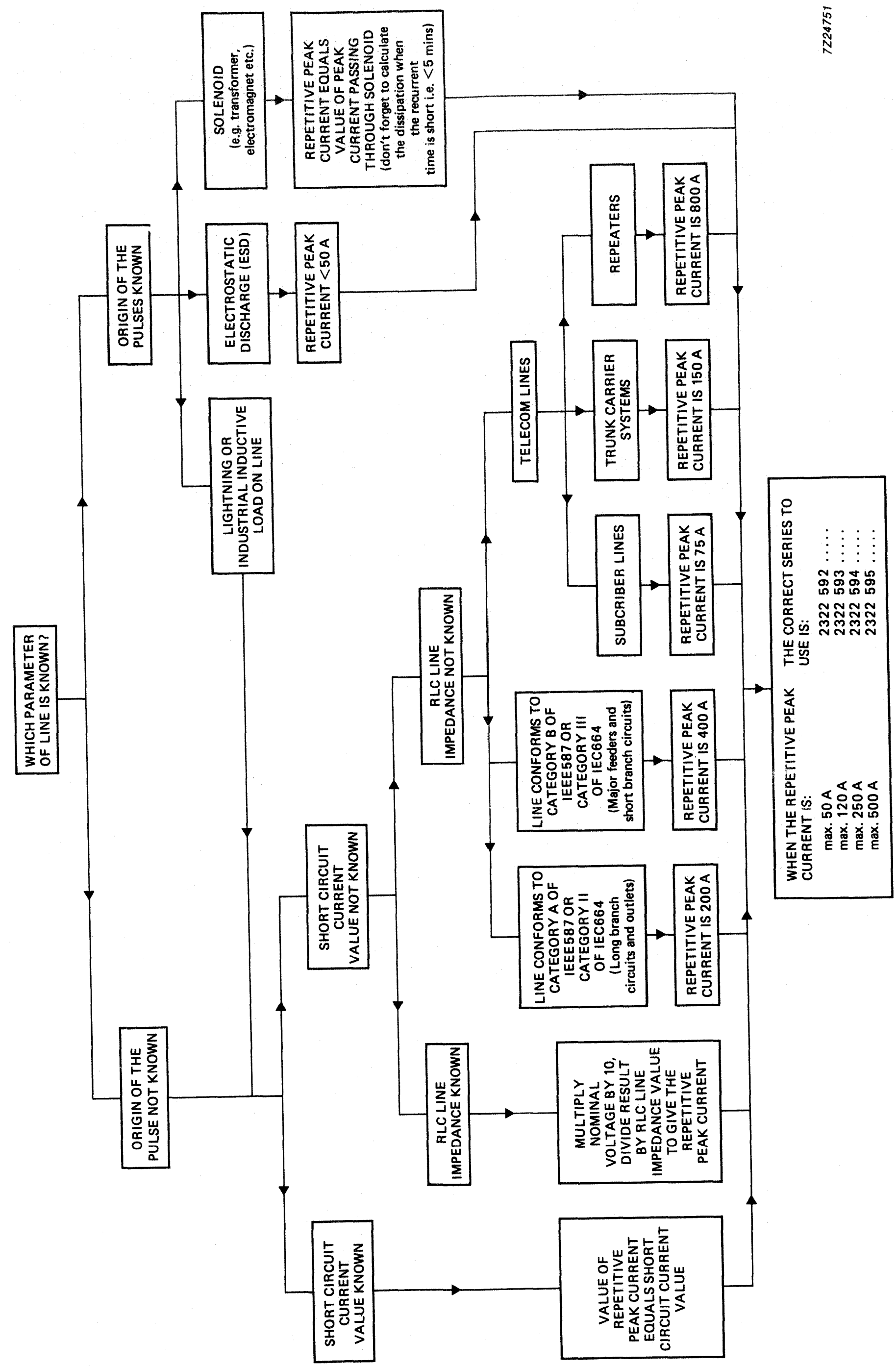
- AC voltage ?
- DC voltage ?

2.What is the maximum RMS or DC voltage?

To ensure correct selection of varistor type, two multichoice selection charts have been prepared:

Chart 1 determines the necessary steady state voltage rating (i.e. working voltage), and chart 2 determines the correct size (i.e. correct energy absorption). These charts can be found on the following pages.


WHAT IS THE VOLTAGE SOURCE?
DC VOLTAGE
AC VOLTAGE
TOLERANCE ON NOMINAL VOLTAGE KNOWN
TOLERANCE ON NOMINAL VOLTAGE NOT KNOWN
ADD TOLERANCE VALUE TO NOMINAL VOLTAGE
MULTIPLY NOMINAL VOLTAGE BY 1.20
SELECT THE NEXT DC VOLTAGE GREATER THAN CALCULATED VOLTAGE USING "MAXIMUM CONTINUOUS DC VOLTAGE" COLUMN IN TABLE 6 OF THE DATA SHEET
VOLTAGE IS SINUSOIDAL
VOLTAGE IS NOT SINUSOIDAL
TOLERANCE ON NOMINAL VOLTAGE KNOWN
TOLERANCE ON NOMINAL VOLTAGE NOT KNOWN
MAXIMUM CREST VOLTAGE KNOWN
MAXIMUM CREST VOLTAGE NOT KNOWN
ADD TOLERANCE VALUE TO NOMINAL VOLTAGE
MULTIPLY NOMINAL VOLTAGE BY 1.15
MULTIPLY MAXIMUM CREST VOLTAGE BY 0.707
MULTIPLY NOMINAL VOLTAGE BY 1.20
SELECT THE NEXT AC VOLTAGE GREATER THAN CALCULATED VOLTAGE USING "MAXIMUM CONTINUOUS AC VOLTAGE" COLUMN IN TABLE 6 OF THE DATA SHEET
GO TO MULTICHOICE CHART 2 SELECTION OF REPETITIVE PEAK CURRENT
7Z24750


7Z24751
WHICH PARAMETER OF LINE IS KNOWN?
ORIGIN OF THE PULSES KNOWN
SOLENOID (e.g. transformer, electromagnet etc.)
REPETITIVE PEAK CURRENT EQUALS VALUE OF PEAK CURRENT PASSING THROUGH SOLENOID (don't forget to calculate the dissipation when the recurrent time is short i.e. <5 mins)
ELECTROSTATIC DISCHARGE (ESD)
REPETITIVE PEAK CURRENT <50 A
LIGHTNING OR INDUSTRIAL INDUCTIVE LOAD ON LINE
ORIGIN OF THE PULSE NOT KNOWN
SHORT CIRCUIT CURRENT VALUE NOT KNOWN
RLC LINE IMPEDANCE NOT KNOWN
TELECOM LINES
REPEATERS
REPETITIVE PEAK CURRENT IS 800 A
TRUNK CARRIER SYSTEMS
REPETITIVE PEAK CURRENT IS 150 A
SUBCRIBER LINES
REPETITIVE PEAK CURRENT IS 75 A
LINE CONFORMS TO CATEGORY B OF IEEE587 OR CATEGORY III OF IEC664 (Major feeders and short branch circuits)
REPETITIVE PEAK CURRENT IS 400 A
LINE CONFORMS TO CATEGORY A OF IEEE587 OR CATEGORY II OF IEC664 (Long branch circuits and outlets)
REPETITIVE PEAK CURRENT IS 200 A
RLC LINE IMPEDANCE KNOWN
MULTIPLY NOMINAL VOLTAGE BY 10, DIVIDE RESULT BY RLC LINE IMPEDANCE VALUE TO GIVE THE REPETITIVE PEAK CURRENT
SHORT CIRCUIT CURRENT VALUE KNOWN
VALUE OF REPETITIVE PEAK CURRENT EQUALS SHORT CIRCUIT CURRENT VALUE
WHEN THE REPETITIVE PEAK CURRENT IS:
max. 50 A
max. 120 A
max. 250 A
max. 500 A
THE CORRECT SERIES TO USE IS:
2322 592 .....
2322 593 .....
2322 594 .....
2322 595 .....

VARISTORS
zinc oxide disc, epoxy coated

QUICK REFERENCE DATA

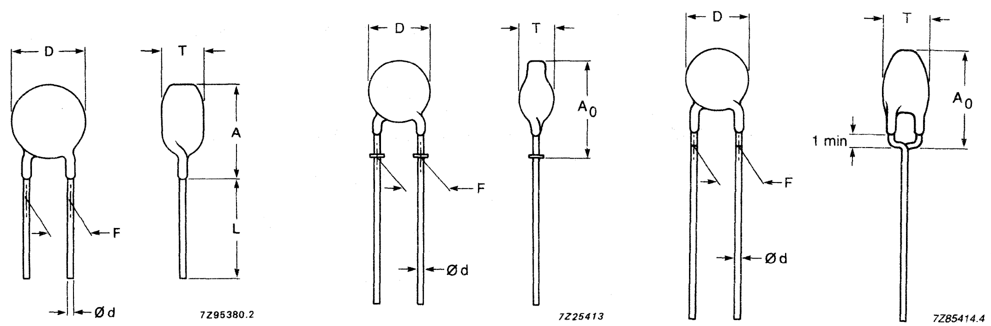
Maximum AC voltage (RMS)	14 to 550 V
Maximum DC voltage	18 to 745 V
Maximum non-repetitive transient current (8/20 μs)	100 to 4500 A
Climatic category	40/125/56
Specification	based on CECC 42 000
Packaging	
2322 592 and 2322 593	on tape on reel
	on tape in 'ammopack' and in bulk
2322 594 and 2322 595	on tape on reel and in bulk

APPLICATION
Suppression of transients to increase contact life and improve electronic equipment reliability.

DESCRIPTION
The varistors consist of a disc of low-β ceramic material with two tinned solid copper wires. They are coated with layers of ochre-coloured epoxy, which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents in accordance with IEC 68-2-45.
Three types of lead configuration are available:

- straight leads
- straight leads with flange (592, 593 series only)
- kinked leads (592, 593 series only)

MECHANICAL DATA
Outlines



Straight leads — Straight leads with flange — Kinked leads

Fig.1 Survey of component outlines; see Table 1 for details.

MECHANICAL DATA (continued)

Table 1 Component dimensions

catalogue number	D max. mm	A max. mm	A_O max. mm	L min. mm	d ± 10% mm	F mm	T mm
2322 592	7	9	11	20	0.6	5 + 0.8/–0.2	see Table 6
2322 593	9	11	13	19	0.6	5 + 0.8/–0.2	see Table 6
2322 594	13.5	15.5		17	0.8	7.62 ± 1	see Table 6
2322 595	17	19		16	0.8	7.62 ± 1	see Table 6

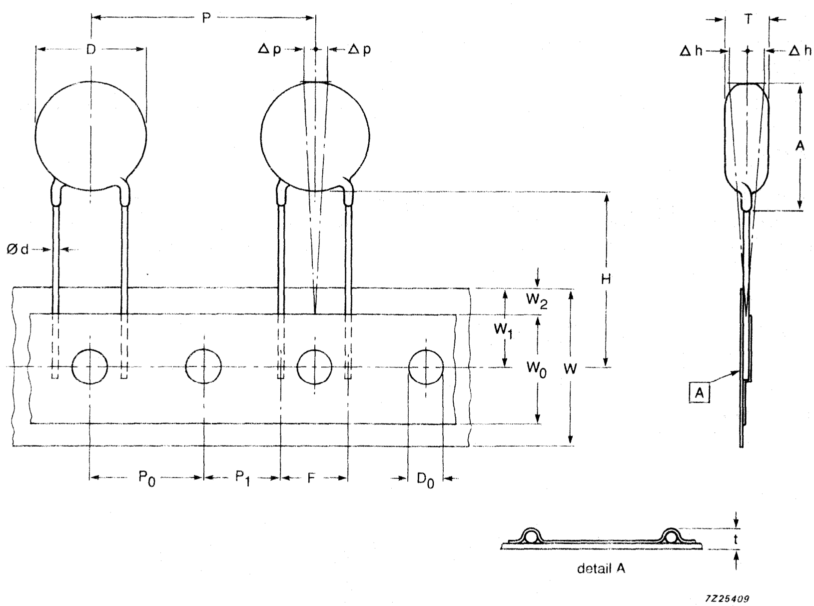


Fig.2 Taped version with straight leads; see Table 2 for details.

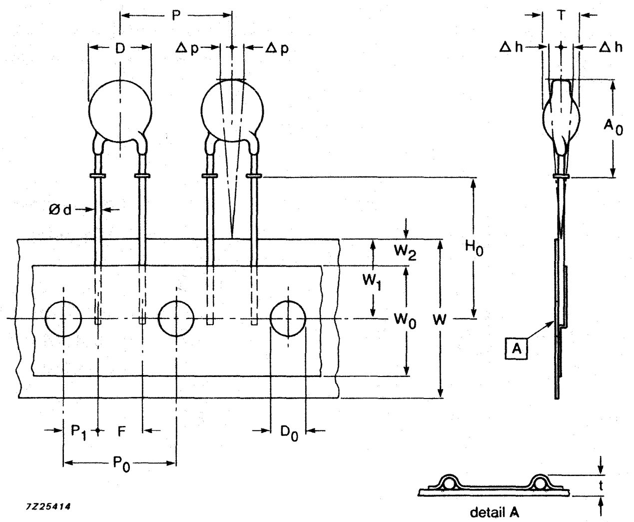


Fig.3 Taped version with flanged leads; see Table 2 for details.

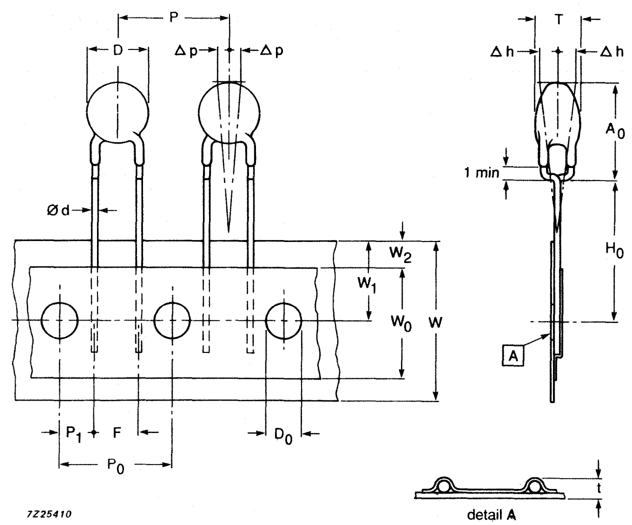


Fig.4 Taped version with kinked leads; see Table 2 for details.

Table 2 Taping data (based on IEC 286-2)

parameter	symbol	nominal dimensions mm	tolerance	remarks
body diameter	D	see Table 1		
total thickness	T	see Table 6		
mounting height	$A_0 - A$	see Table 1		
lead wire diameter	d	see Table 1		
lead to lead distance	F	see Table 1		guaranteed between component and tape
component pitch	P	12.7/25.4 mm	± 1 mm	
feed hole pitch	P_0	12.7	± 0.3	cumulative pitch error = ± 1 mm/20 pitches
feed hole centre to lead centre	P_1	3.81/8.89	± 0.7	guaranteed between component and tape
component alignment	ΔP	0	± 1.3	
component alignment	Δh	0	± 2.0	
tape width	W	18	+ 1/–0.5	
hold down tape width	W_0	12.5 min.		
hole position	W_1	9	± 0.5	
hold down tape position	W_2	3 max.		
height between component and tape centre	H	20	+ 2/–0	straight lead versions
lead wire clinch height	H_0	16/18.25	± 0.5	flanged and kinked lead versions
feed hole diameter	D_0	4	± 0.2	
total tape thickness	t	0.9 max.		cardboard tape 0.5 ± 0.1
AQL - mechanical level II			± 1%	

MECHANICAL DATA (continued)

Mounting

The varistors are suitable for processing on automatic insertion, and cutting and bending equipment.

Versions with flanged leads provide better positioning on the PCB and more accurate control over component height. This is important for hand mounting and automatic insertion techniques (see Fig.5).

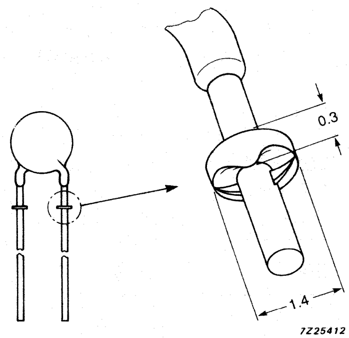


Fig.5 Varistor with flanged lead.

Soldering

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

Impact

Free fall	1 m

Robustness of terminations

Tensile strength	10 N

Inflammability

The varistors are non-flammable

Marking

The varistors are marked with the following information:

- maximum continuous RMS voltage
- series number (i.e. 592, 593, 594 or 595)
- manufacturer's logo
- date of manufacture

ORDERING INFORMATION

Packaging

The varistors are available in a number of packing options:

- on tape on reel
- on tape in 'ammopack'
- bulk packing

The basic ordering code for each option is given in Tables 3 to 5 inclusive. To complete the catalogue number consult Table 6, Electrical Data, to determine the required operating parameters.

Table 3 Varistors available on tape on reel

	2322 592 (ϕ 7 mm) 14 - 460 V	2322 593 (ϕ 10 mm) 14 - 460 V	2322 594 (ϕ 13.5 mm) 14 - 550 V	2322 595 (ϕ 17 mm) 14 - 550 V
packing quantity	1500	1500	750	750
straight leads; H = 20 (see Fig.2)	0 . . . 6	0 . . . 6	0 . . . 6	0 . . . 6
straight leads with flange; H_0 = 16 (see Fig.3)	1 . . . 6	1 . . . 6		
straight leads with flange; H_0 = 18.25 (see Fig.3)	2 . . . 6	2 . . . 6		
kinked leads; H_0 = 18.25 (see Fig.4)	3 . . . 6	3 . . . 6		
kinked leads; H_0 = 16 (see Fig.4)	8 . . . 6	8 . . . 6		

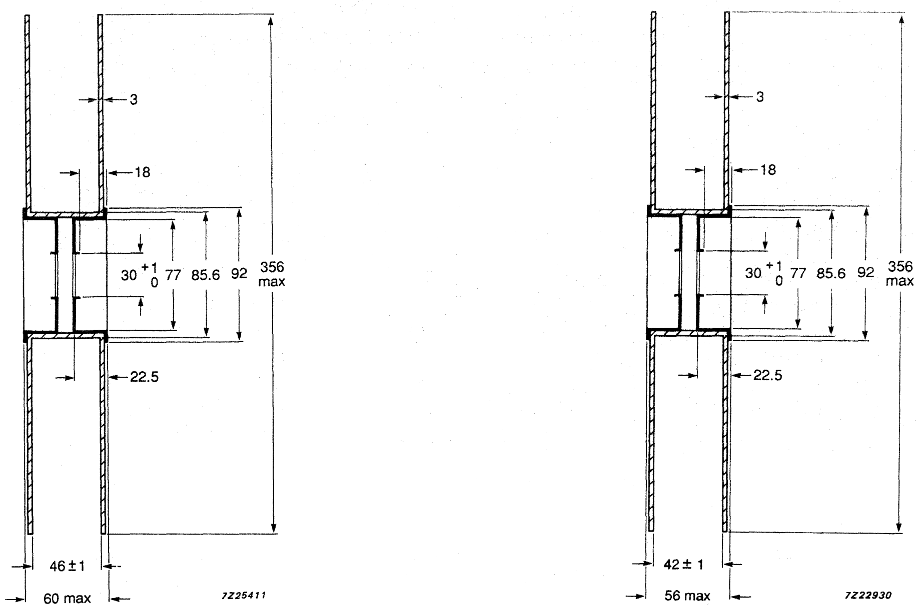


Fig.6 Dimensions of reels.

Table 4 Varistors available on tape in 'ammopack'

	2322 592 (ϕ 7 mm) 14 - 460 V	2322 593 (ϕ 10 mm) 14 - 460 V
packing quantity	1500/2000	1500/2000
straight leads; H = 20 (see Fig.2)	0 . . . 7	0 . . . 7
straight leads with flange; H_0 = 16 (see Fig.3)	1 . . . 7	1 . . . 7
straight leads with flange; H_0 = 18.25 (see Fig.3)	2 . . . 7	2 . . . 7
kinked leads; H_0 = 18.25 (see Fig.4)	3 . . . 7	3 . . . 7
kinked leads; H_0 = 16 (see Fig.4)	8 . . . 7	8 . . . 7

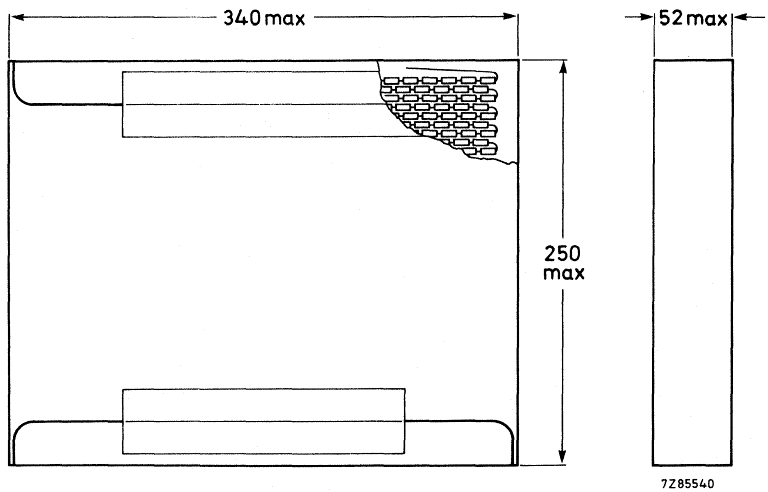


Fig.7 Dimensions of 'ammopack'.

Table 5 Varistors available in bulk

	2322 592 (ϕ 7 mm) 14 - 460 V	2322 593 (ϕ 10 mm) 14 - 460 V	2322 594 (ϕ 13.5 mm) 14 - 550 V	2322 595 (ϕ 17 mm) 14 - 550 V
packing quantity	250	250	250	100/250
straight leads; (see Fig.1)	5 . . . 6	5 . . . 6	5 . . . 6	5 . . . 6
straight leads with flange; (see Fig.1)	7 . . . 6	7 . . . 6		
kinked leads; (see Fig.1)	6 . . . 6	6 . . . 6		

ELECTRICAL DATA

Climatic category	40/125/56
Maximum continuous voltage	
RMS	14 to 550 V
DC	18 to 745 V
Maximum withstanding surge current (8 x 20 μs)	
2322 592	100 or 400 A
2322 593	250 or 1200 A
2322 594	500 or 2500 A
2322 595	1000 or 4500 A
Temperature coefficient of voltage at 1 mA max.	−0.065 %/K
Insulation voltage	2500 V

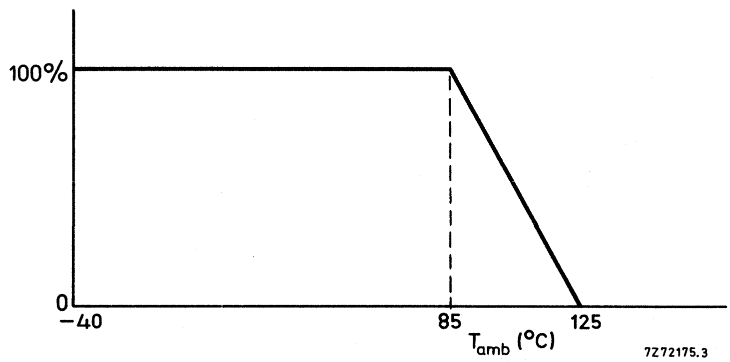


Fig.8 Derating curve.

Table 6 Electrical parameters

catalogue number 2322 . . . . followed by	maximum continuous voltage		voltage at 1 mA (note 2)		maximum voltage at stated current (8 x 20 μs) (note 3)		maximum energy (10 x 1000 μs) (note 4)	maximum non-repetitive surge current (8 x 20 μs)	typical capacitance at 1 kHz	maximum thickness
	V (RMS) (note 1)	V (DC)	V (min.)	V (max.)	V	A	J	A	pF	T (mm)
592 . 140 6	14	18	20	24	48	1	0.5	100	1300	4.5
593 . 140 6					43	2.5	1.7	250	2800	4.6
594 . 140 6					43	5	4.3	500	6000	4.7
595 . 140 6					43	10	5.4	1000	15000	4.7
592 . 170 6	17	22	24	30	60	1	0.7	100	1050	4.5
593 . 170 6					53	2.5	2.0	250	2000	4.7
594 . 170 6					53	5	5.3	500	4000	4.8
595 . 170 6					53	10	6.9	1000	10000	4.8
592 . 200 6	20	26	30	36	73	1	0.8	100	900	4.5
593 . 200 6					65	2.5	2.5	250	1500	4.9
594 . 200 6					65	5	6.5	500	3000	5.0
595 . 200 6					65	10	8.8	1000	7500	5.0
592 . 250 6	25	31	35	43	86	1	0.9	100	500	4.5
593 . 250 6					77	2.5	3.0	250	1350	4.9
594 . 250 6					77	5	7.7	500	2600	5.1
595 . 250 6					77	10	9.4	1000	6500	5.1
592 . 300 6	30	38	42	52	96	1	1.1	100	700	4.1
593 . 300 6					93	2.5	3.6	250	1600	4.1
594 . 300 6					93	5	9.2	500	2700	4.4
595 . 300 6					90	10	12	1000	6000	4.4
592 . 350 6	35	45	50	62	123	1	1.4	100	560	4.1
593 . 350 6					115	2.5	4.4	250	1300	4.1
594 . 350 6					110	5	11	500	2200	4.4
595 . 350 6					105	10	14	1000	4800	4.4
592 . 400 6	40	56	61	75	145	1	1.6	100	460	4.1
593 . 400 6					135	2.5	5.2	250	1000	4.1
594 . 400 6					130	5	13	500	1800	4.4
595 . 400 6					130	10	17	1000	3800	4.4

Replace last digit of catalogue number with a '7' for ordering on tape in ammopack (592, 593 series only).

catalogue number 2322 . . . . followed by	maximum continuous voltage		voltage at 1 mA (note 2)		maximum voltage at stated current (8 x 20 μs) (note 3)		maximum energy (10 x 1000 μs) (note 4)	maximum non-repetitive surge current (8 x 20 μs)	typical capacitance at 1 kHz	maximum thickness
	V (RMS) (note 1)	V (DC)	V (min.)	V (max.)	V	A	J	A	pF	T (mm)
592 . 500 6	50	65	74	90	145	5	2.6	400	370	4.1
593 . 500 6					140	10	7.0	1200	900	4.1
594 . 500 6					140	25	12	2500	1500	4.4
595 . 500 6					140	50	21	4500	3100	4.4
592 . 600 6 *	60	85	90	110	165	5	2.9	400	290	4.1
593 . 600 6 *					165	10	8.3	1200	700	4.1
594 . 600 6 *					165	25	15	2500	1200	4.4
595 . 600 6 *					165	50	24	4500	2300	4.4
592 . 750 6 *	75	100	108	132	190	5	3.4	400	240	4.1
593 . 750 6 *					200	10	10	1200	530	4.1
594 . 750 6 *					200	25	18	2500	1000	4.4
595 . 750 6 *					200	50	29	4500	1900	4.4
592 . 950 6 *	95	125	135	165	230	5	4.1	400	180	4.1
593 . 950 6 *					250	10	13	1200	450	4.1
594 . 950 6 *					250	25	22	2500	800	4.4
595 . 950 6 *					250	50	37	4500	1500	4.4
592 . 131 6 *	130	170	185	225	310	5	5.5	400	130	4.1
593 . 131 6 *					340	10	17	1200	320	4.1
594 . 131 6 *					340	25	30	2500	580	4.6
595 . 131 6 *					340	50	56	4500	1050	4.6
592 . 141 6	140	180	192	242	350	5	6.3	400	120	4.4
593 . 141 6					370	10	21	1200	290	4.4
594 . 141 6					370	25	33	2500	540	4.8
595 . 141 6					370	50	57	4500	950	4.8
592 . 151 6 *	150	200	216	264	395	5	7.1	400	110	4.4
593 . 151 6 *					400	10	20	1200	270	4.4
594 . 151 6 *					400	25	36	2500	490	4.8
595 . 151 6 *					400	50	59	4500	850	4.8

Replace last digit of catalogue number with a '7' for ordering on tape in ammopack (592, 593 series only).
*CECC approved types

catalogue number 2322 . . . . followed by	maximum continuous voltage		voltage at 1 mA (note 2)		maximum voltage at stated current (8 x 20 μs) (note 3)		maximum energy (10 x 1000 μs) (note 4)	maximum non-repetitive surge current (8 x 20 μs)	typical capacitance at 1 kHz	maximum thickness
V	V (RMS) (note 1)	V (DC)	V (min.)	V (max.)	V	A	J	A	pF	T (mm)
592 . 171 6 *	175	225	247	303	410	5	7.3	400	90	4.6
593 . 171 6 *					455	10	23	1200	230	4.6
594 . 171 6 *					455	25	41	2500	430	5.0
595 . 171 6 *					455	50	67	4500	750	5.0
592 . 231 6 *	230	300	324	396	560	5	10	400	70	4.9
593 . 231 6 *					600	10	30	1200	170	4.9
594 . 231 6 *					600	25	54	2500	320	5.4
595 . 231 6 *					600	50	88	4500	540	5.4
592 . 251 6 *	250	320	351	429	600	5	11	400	60	4.9
593 . 251 6 *					650	10	33	1200	160	4.9
594 . 251 6 *					650	25	58	2500	300	5.4
595 . 251 6 *					650	50	96	4500	480	5.4
592 . 271 6 *	275	350	387	473	695	5	12	400	55	4.9
593 . 271 6 *					710	10	36	1200	140	4.9
594 . 271 6 *					710	25	63	2500	270	5.4
595 . 271 6 *					710	50	104	4500	440	5.4
592 . 301 6 *	300	385	423	517	750	5	13	400	50	5.3
593 . 301 6 *					800	10	40	1200	130	5.3
594 . 301 6 *					800	25	71	2500	240	5.9
595 . 301 6 *					800	50	117	4500	400	5.9
592 . 381 6	385	505	558	682	1000	5	18	400	40	5.8
593 . 381 6					1025	10	51	1200	95	5.8
594 . 381 6					1025	25	67	2500	180	6.6
595 . 381 6					1025	50	110	4500	280	6.6
592 . 421 6 *	420	560	612	748	1100	5	20	400	35	5.9
593 . 421 6 *					1120	10	56	1200	85	5.9
594 . 421 6 *					1120	25	73	2500	165	6.6
595 . 421 6 *					1120	50	120	4500	250	6.6

Replace last digit of catalogue number with a '7' for ordering on tape in ammopack (592, 593 series only).

*CECC approved types

Table 6 (continued)

catalogue number 2322 . . . . followed by	maximum continuous voltage		voltage at 1 mA (note 2)		maximum voltage at stated current (8 x 20 μs) (note 3)		maximum energy (10 x 1000 μs) (note 4)	maximum non-repetitive surge current (8 x 20 μs)	typical capacitance at 1 kHz	maximum thickness
	V (RMS) (note 1)	V (DC)	V (min.)	V (max.)	V	A	J	A	pF	T (mm)
592 . 461 6 *	460	615	675	825	1200	5	21	400	30	6.0
593 . 461 6 *					1240	10	63	1200	75	6.0
594 . 461 6 *					1240	25	82	2500	150	6.6
595 . 461 6 *					1240	50	135	4500	225	6.6
594 . 511 6	510	670	738	902	1335	25	89	2500	135	6.9
595 . 511 6					1355	50	145	4500	220	6.9
594 . 551 6	550	745	819	1001	1500	25	98	2500	120	7.0
595 . 551 6					1500	50	160	4500	180	7.0

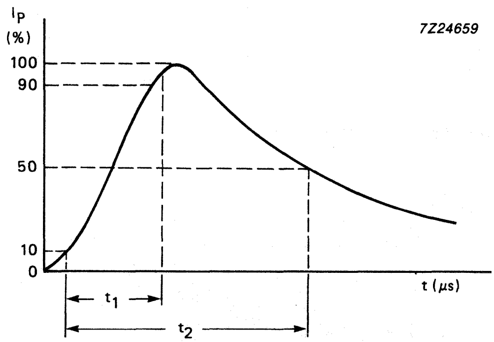
Replace last digit of catalogue number with a '7' for ordering on tape in ammopack (592, 593 series only).
*CECC approved types

Notes to Table 6

1. The sinusoidal voltage is assumed as the normal operating condition. If a non-sinusoidal voltage is present, type selection should be based on multiplying the peak voltage by a factor of 0.707.
2. The voltage measured at 1 mA meets the requirements of para. 4.3 of CECC specification 42 000.
3. A current wave of 8 x 20 μs (requirement of para. B.2.10.1 of CECC specification 42 000) is used as a standard for impulse current and clamping voltage ratings. The maximum non-repetitive surge current is given for one impulse applied during the life of the component.
4. High energy surges are generally of longer duration. The maximum energy for one impulse of 10 x 1000 μs is given as a reference for long duration impulses. This impulse can be characterised by peak current (I_p) and impulse width t_2 (virtual time of half I_p value, following IEC 60-2, Section 6). If V_p is the clamping voltage corresponding to I_p, the energy absorbed in the VDR is determined by the formula:

$$E = K \cdot V_p \cdot I_p \cdot t_2$$

K is dependent on the value of t_2 when the value of t_1 is between 8 and 10 μs (see Fig.9).



t_2 (μs)	K
20	1
50	1.2
100	1.3
1000	1.4

Fig.9 Peak current (I_p) as a function of impulse width (t_2).

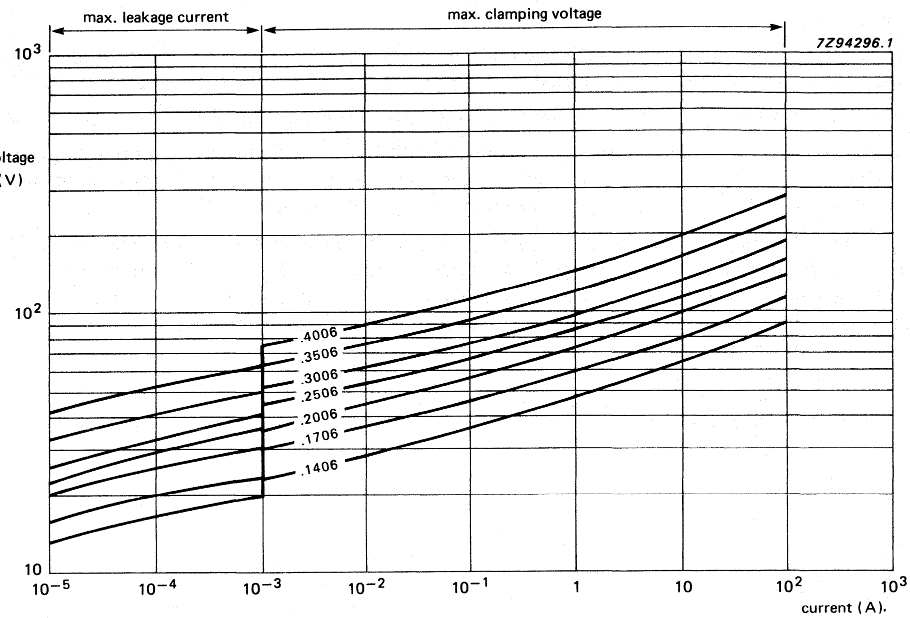


Fig.10 V/I characteristics, 14/40 V; 2322 592 series.

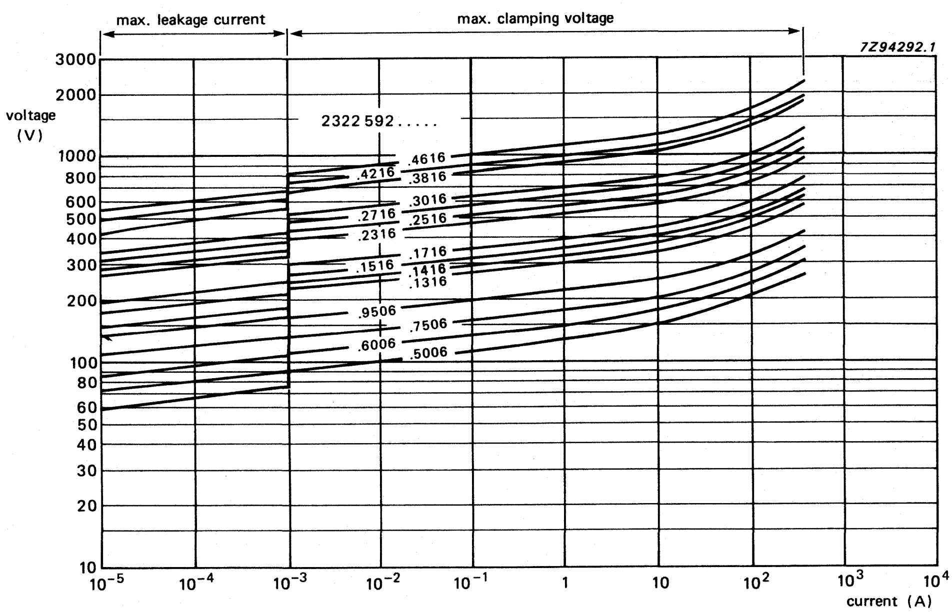


Fig.11 V/I characteristics, 50/460 V; 2322 592 series.

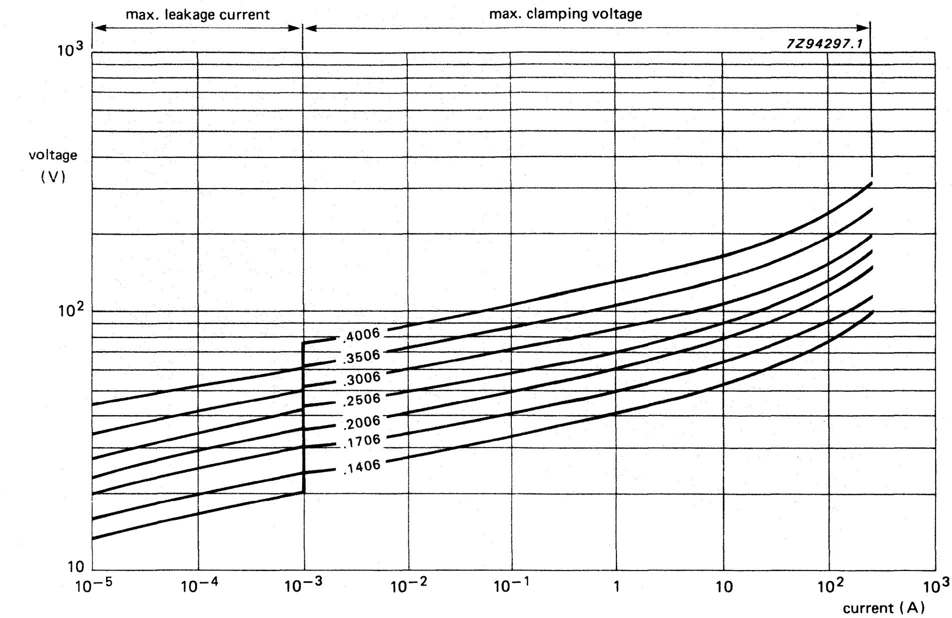


Fig.12 V/I characteristics, 14/40 V; 2322 593 series.

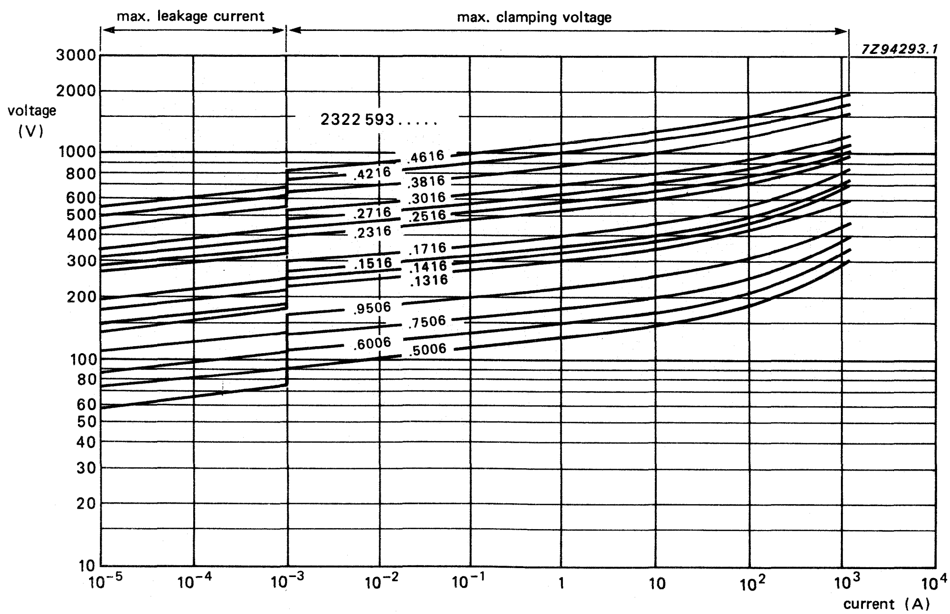


Fig.13 V/I characteristics, 50/460 V; 2322 593 series.

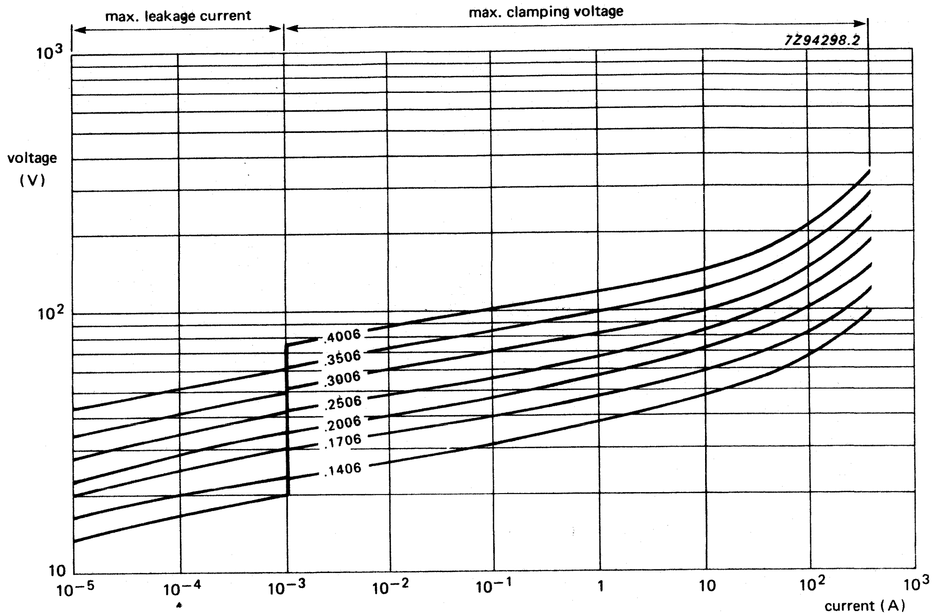


Fig.14 V/I characteristics, 14/40 V; 2322 594 series.

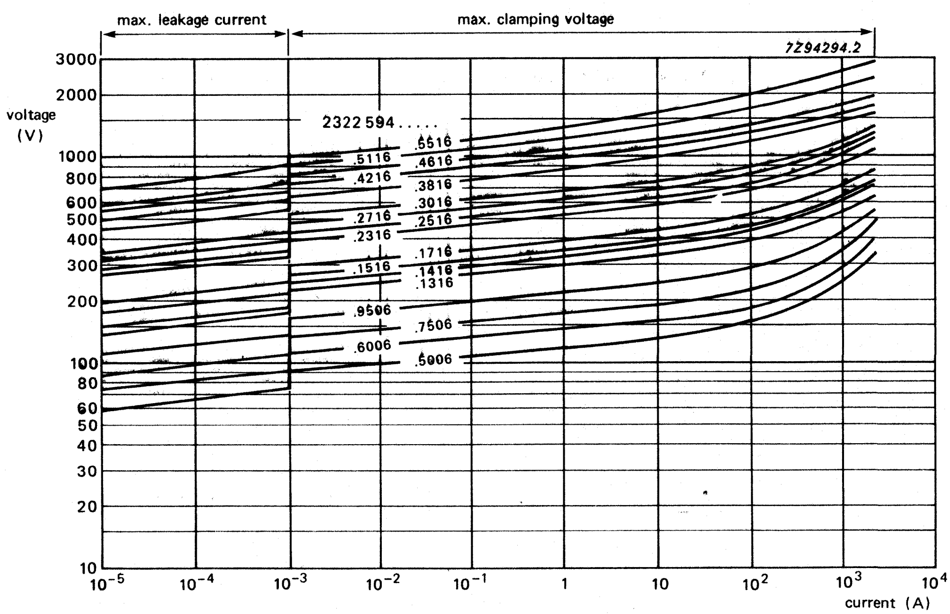


Fig.15 V/I characteristics, 50/550 V; 2322 594 series.

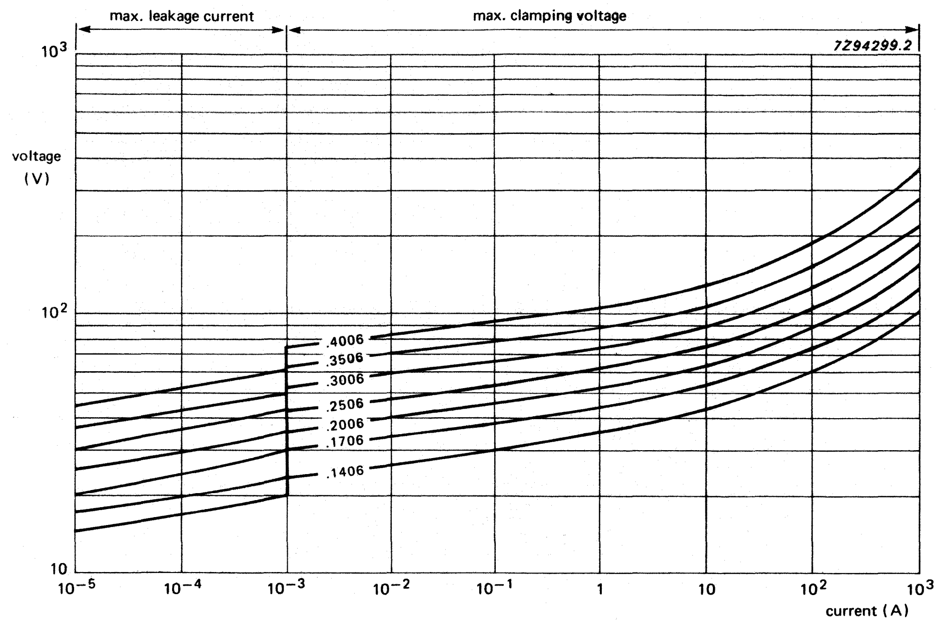


Fig.16 V/I characteristics, 14/40 V; 2322 595 series.

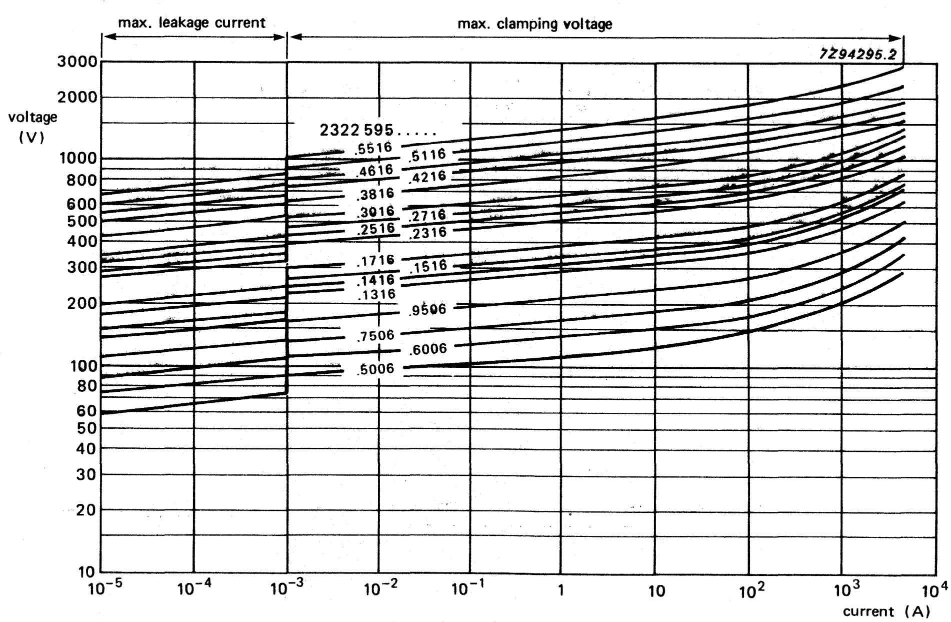


Fig.17 V/I characteristics, 50/550 V; 2322 595 series.

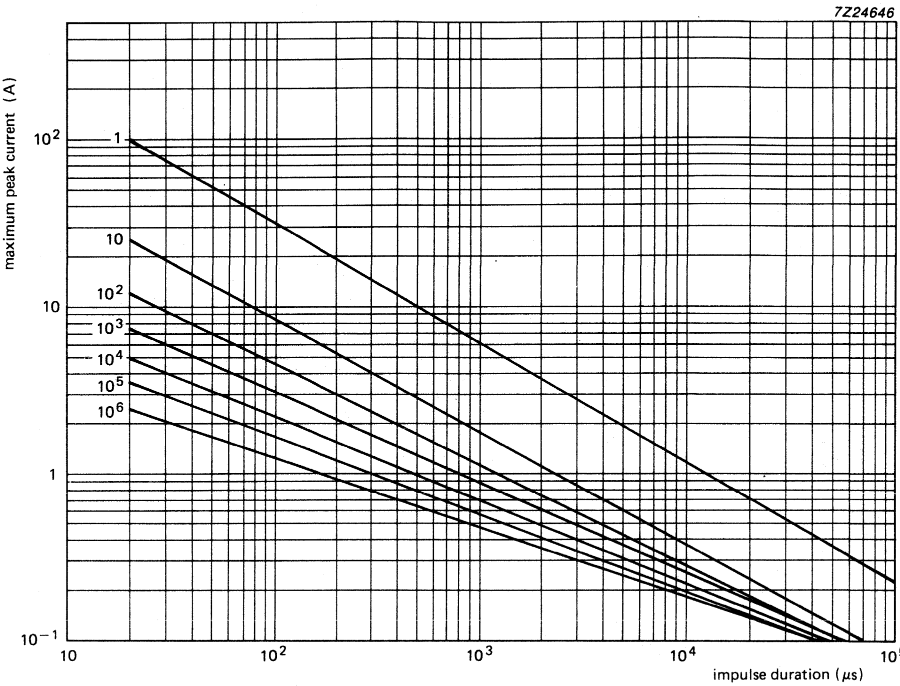


Fig.18 Maximum applicable transient current as a function of impulse duration, 14/40 V; 2322 592 series.

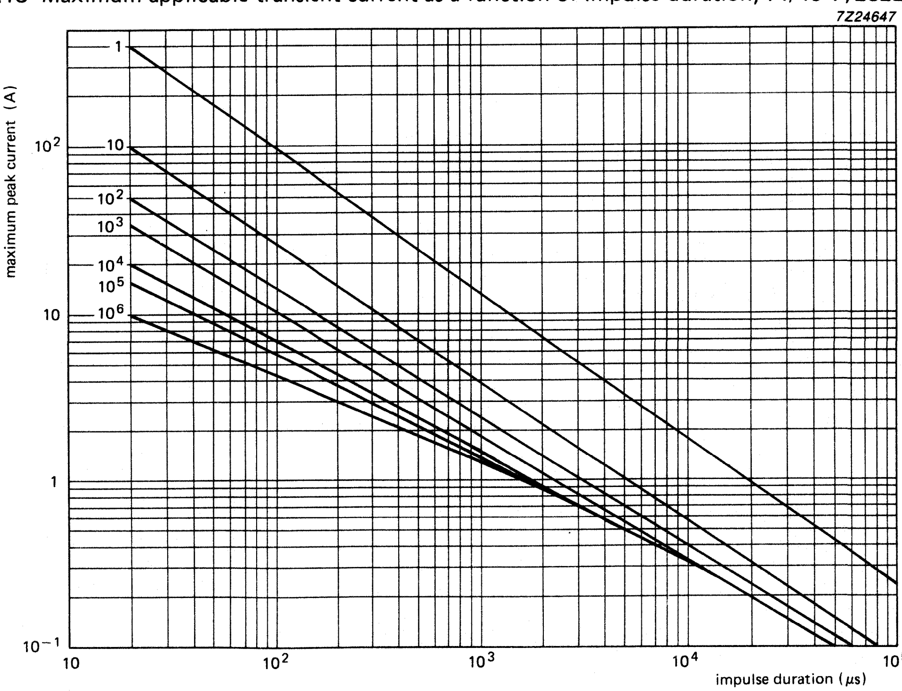


Fig.19 Maximum applicable transient current as a function of impulse duration, 50/460 V; 2322 592 series.

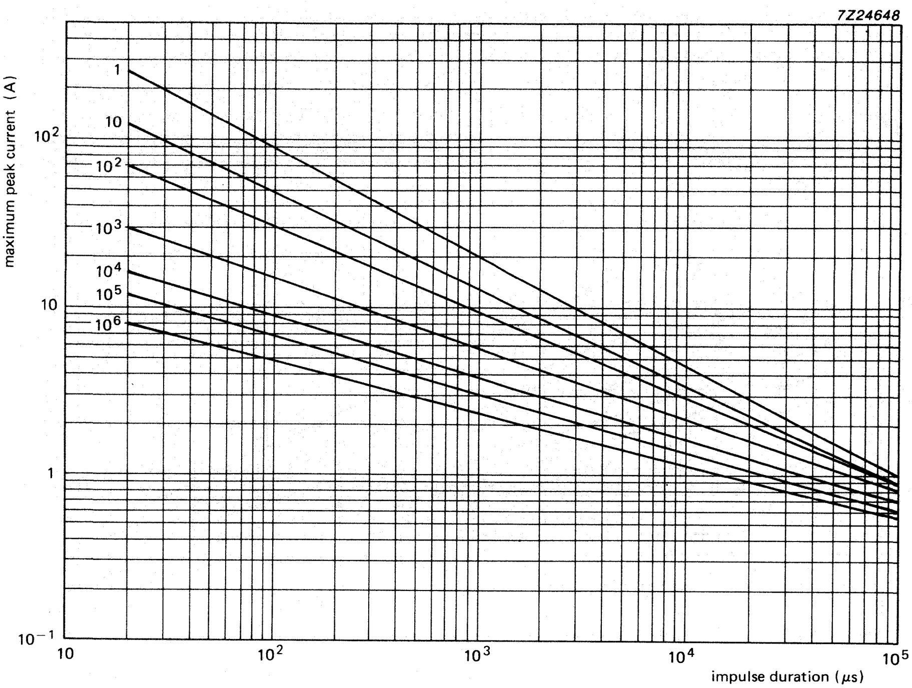


Fig.20 Maximum applicable transient current as a function of impulse duration, 14/40 V; 2322 593 series.

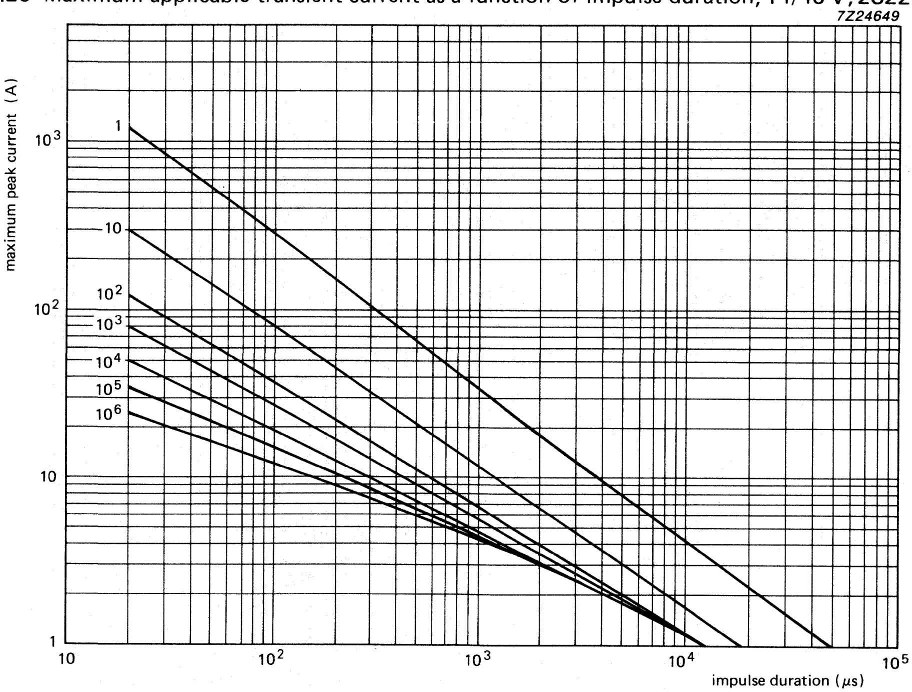


Fig.21 Maximum applicable transient current as a function of impulse duration, 50/460 V; 2322 593 series.

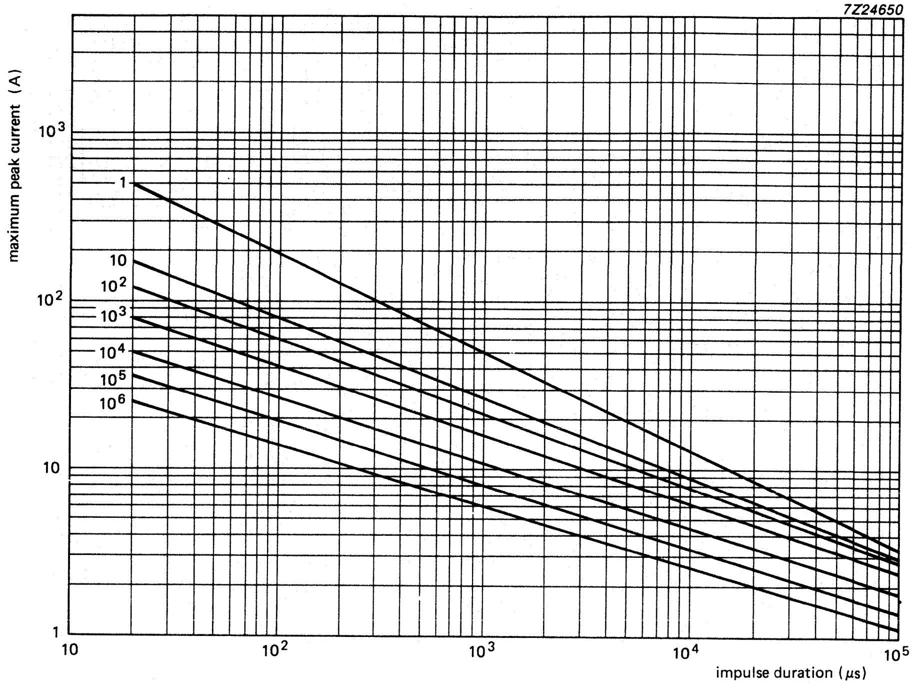


Fig.22 Maximum applicable transient current as a function of impulse duration, 14/40 V; 2322 594 series.

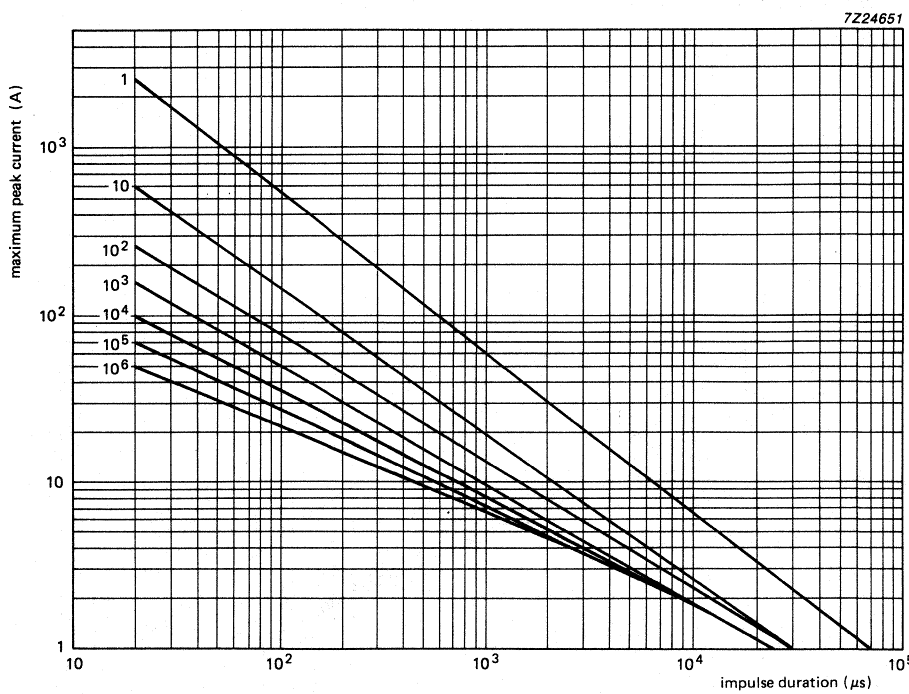


Fig.23 Maximum applicable transient current as a function of impulse duration, 50/300 V; 2322 594 series.

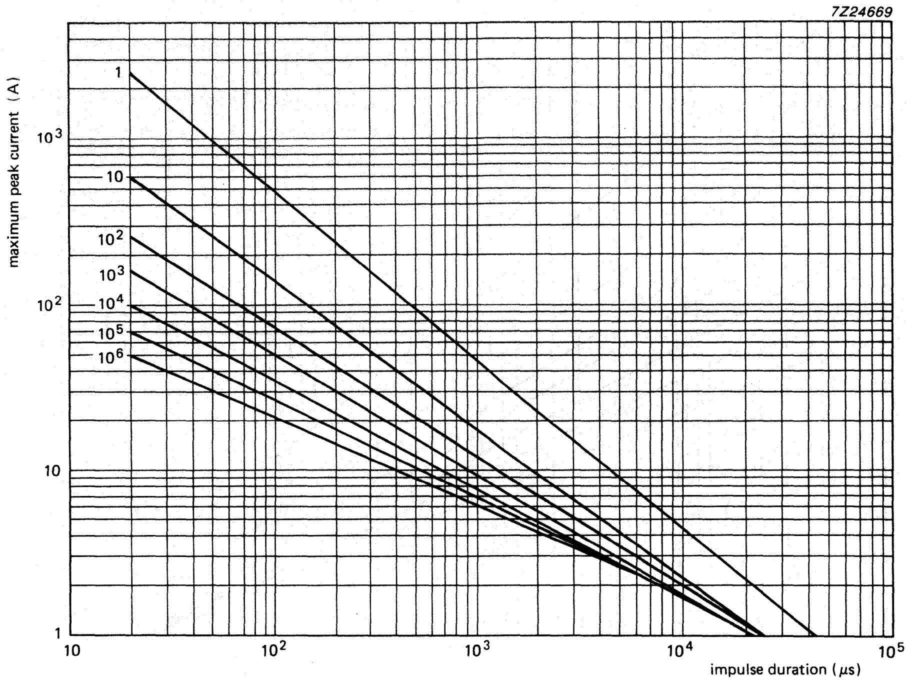


Fig.24 Maximum applicable transient current as a function of impulse duration, 385/550 V; 2322 594 series.

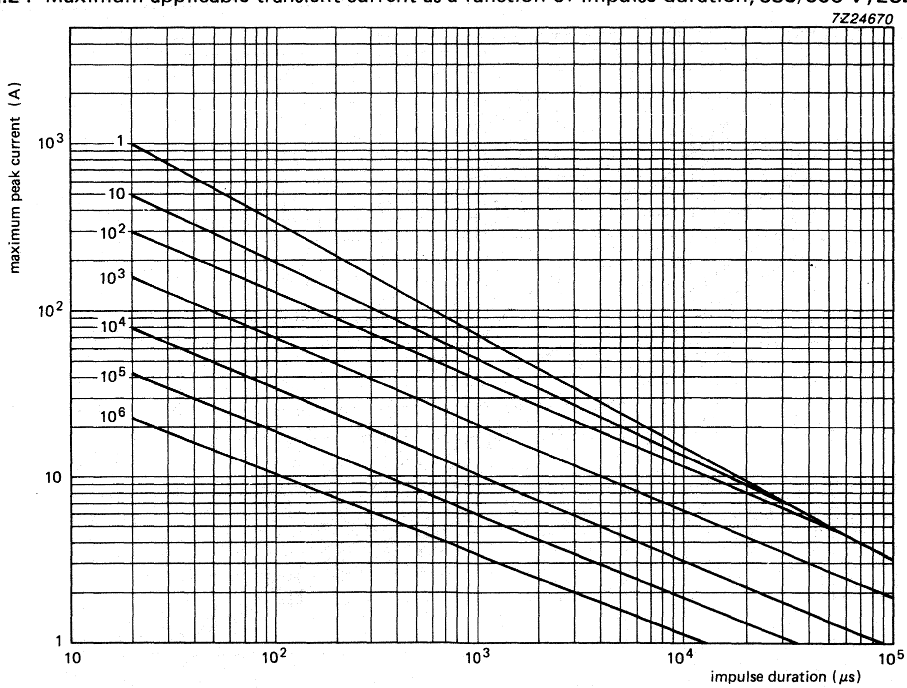


Fig.25 Maximum applicable transient current as a function of impulse duration, 14/40 V; 2322 595 series.

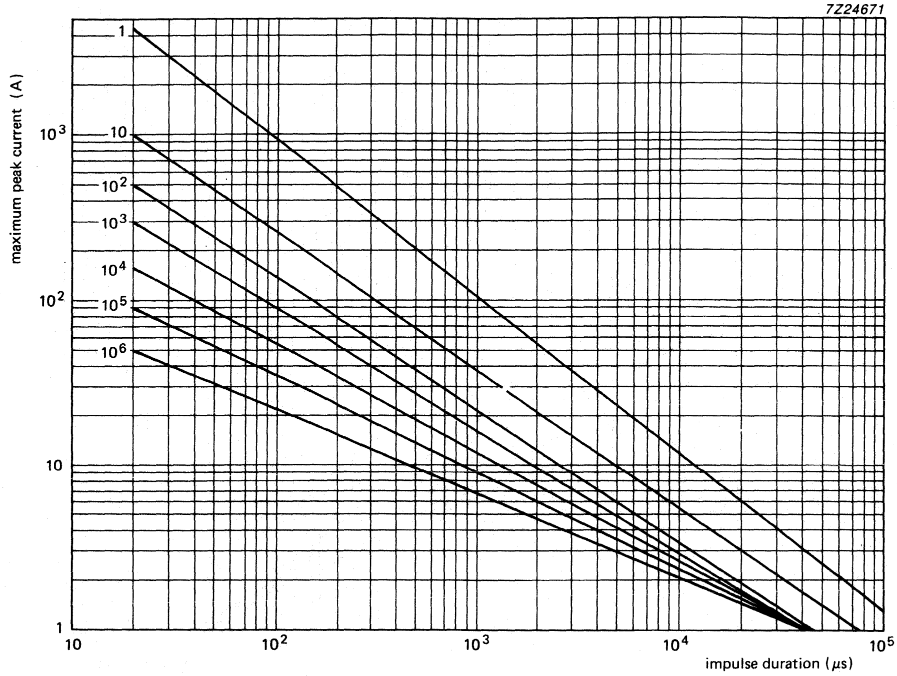


Fig.26 Maximum applicable transient current as a function of impulse duration, 50/300 V; 2322 595 series.

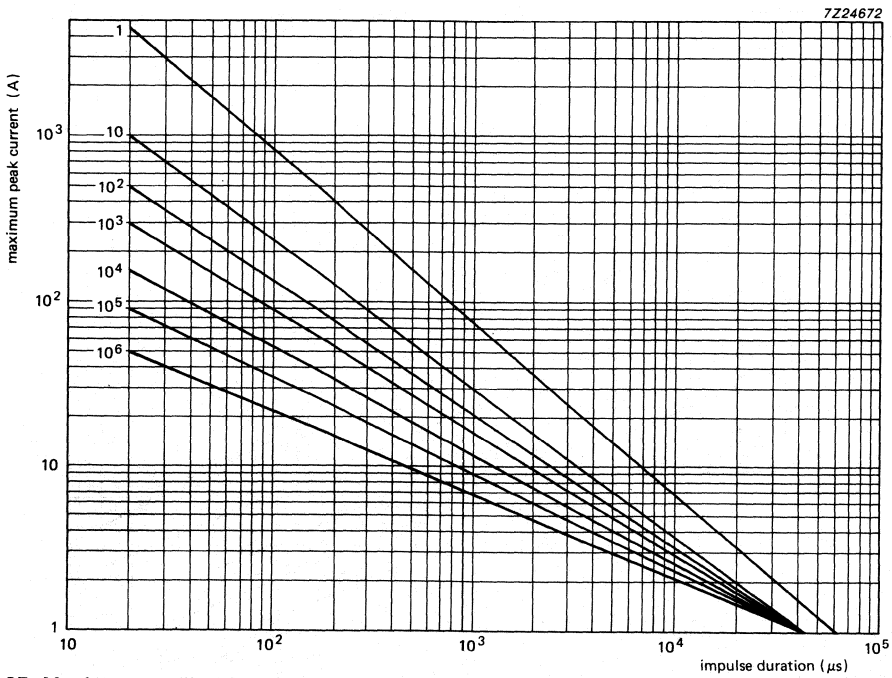


Fig.27 Maximum applicable transient current as a function of impulse duration, 385/550 V; 2322 595 series.

SENSORS

GENERAL

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

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

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

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

SPECTRAL RESPONSE

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

TEMPERATURE DEPENDENCY

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

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

RECOVERY RATE

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

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

SURVEY

minimum dark resistance	light resistance	maximum dissipation at 40 °C	ambient temperature range	catalogue number
10 MΩ	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
Recovery rate			min. 200 kΩ/s	

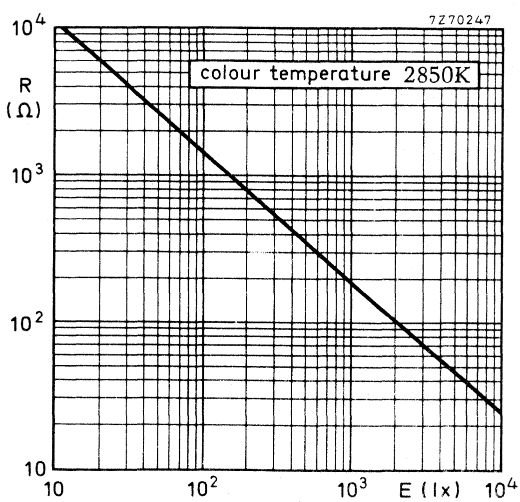
DESCRIPTION

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

APPLICATION

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

TYPICAL CHARACTERISTICS



Resistance as a function of illumination.

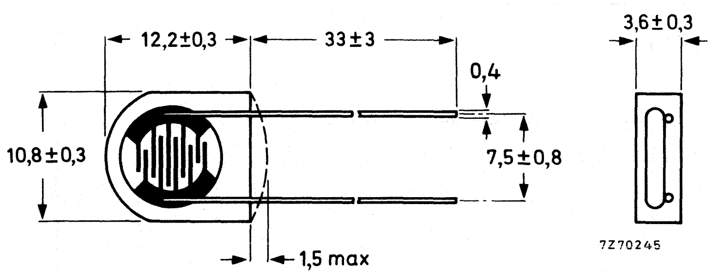
LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA

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

MECHANICAL DATA

Outline drawing



Marking

None

Mass

0,75 g approximately

Mounting

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

Robustness of terminations

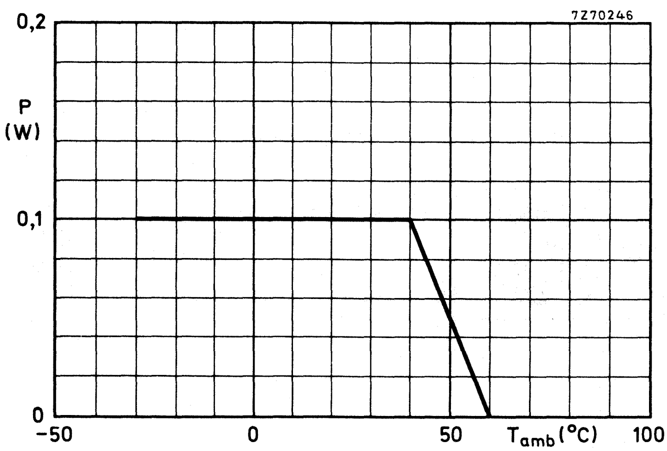
Tensile strength	5 N
Bending	2,5 N

Soldering

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

ELECTRICAL DATA

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



Permissible dissipation as a function of ambient temperature.

PACKAGING

250 per box

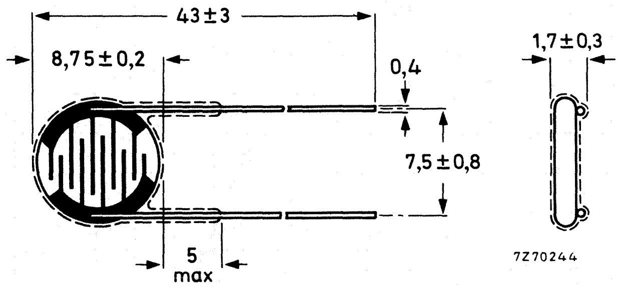
LIGHT DEPENDENT RESISTOR

QUICK REFERENCE DATA

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

MECHANICAL DATA

Outline drawing



Marking

None

Mass

0,35 g approximately

Mounting

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

Robustness of terminations

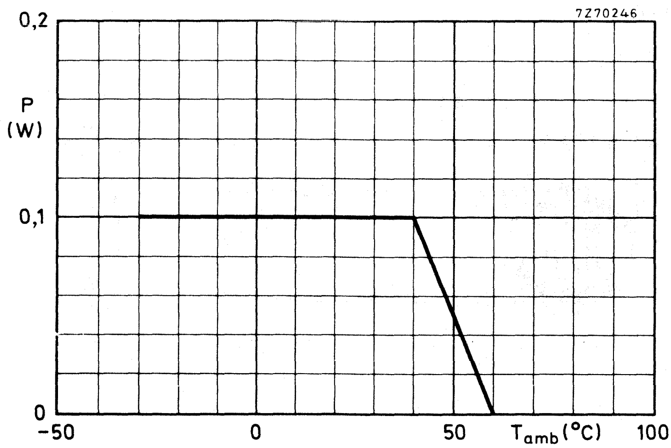
Tensile strength	5 N
Bending	2,5 N

Soldering

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

ELECTRICAL DATA

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



Permissible dissipation as a function of ambient temperature.

PACKAGING

250 per box

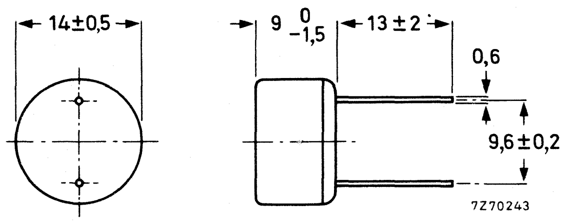
LIGHT DEPENDENT RESISTORS

QUICK REFERENCE DATA

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

MECHANICAL DATA

Outline drawing



Marking

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

Mass

1,3 g approximately.

Mounting

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

Robustness of terminations

Tensile strength	10 N
Bensing	5 N

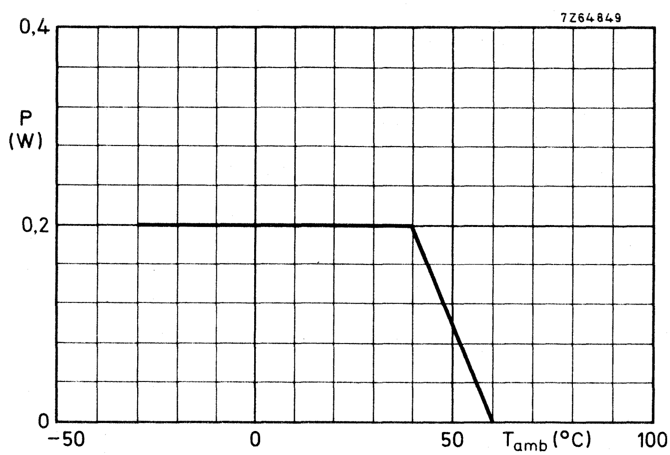
Soldering

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

ELECTRICAL DATA

catalogue number	resistance dark value R_D	resistance light value R_L
2322 600 95001	min. 10 MΩ	75 to 300 Ω
95003	min. 10 MΩ	max. 250 Ω
95006	min. 1 MΩ	max. 110 Ω

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



Permissible dissipation as a function of ambient temperature.

PACKAGING

125 per box

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 12 and 75% R.H.	0,4 ± 0,05 pF/% R.H.
Frequency range	1 kHz to 1 MHz
Maximum AC or DC 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 electronic hygrometers for domestic use, self-regulating air humidifiers, etc.

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, nor to chlorine vapours.

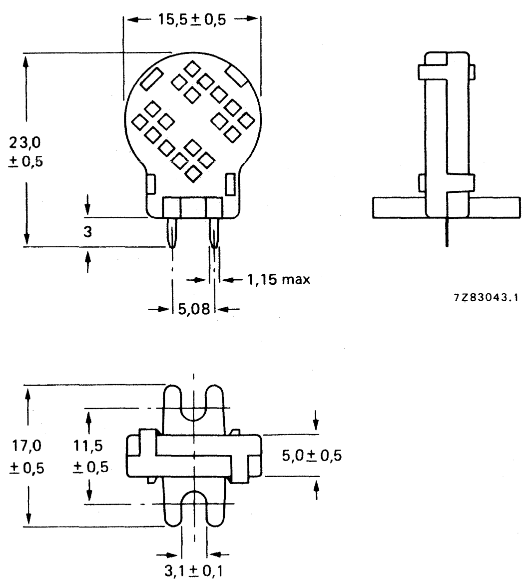


Fig. 1 Dimensions in mm.

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, 100 kHz and 43% R.H.	$\leqslant$ 0.035
→ Sensitivity between 12 and 75% 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

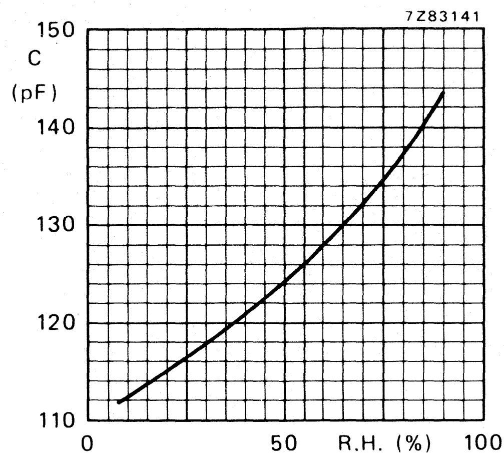


Fig. 2 Typical capacitance/relative humidity characteristic.

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.

NOTES

DATA HANDBOOK SYSTEM

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of six series of handbooks:

INTEGRATED CIRCUITS

DISCRETE SEMICONDUCTORS

DISPLAY COMPONENTS

PASSIVE COMPONENTS*

PROFESSIONAL COMPONENTS**

MATERIALS*

The contents of each series are listed on pages iii to viii.

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

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application is given it is advisory and does not form part of the product specification.

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Product specialists are at your service and enquiries will be answered promptly.

* Will replace the Components and materials (green) series of handbooks.
** Will replace the Electron tubes (blue) series of handbooks.

INTEGRATED CIRCUITS

This series of handbooks comprises:

code	handbook title
IC01	**Radio, audio and associated systems** Bipolar, MOS
IC02a/b	**Video and associated systems** Bipolar, MOS
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IC15	**FAST TTL logic series**
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S4a	**SC05**	**Low-frequency power transistors and hybrid IC power modules**
S4b	**SC06**	**High-voltage and switching power transistors**
S5	**SC07**	**Small-signal field-effect transistors**
S6	**SC08** **SC09**	**RF power transistors** **RF power modules**
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S8b	**SC12**	**Optocouplers**
S9	**SC13***	**PowerMOS transistors**
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S14	**SC18***	**Liquid crystal displays and driver ICs for LCDs**

* Not yet issued with the new code in this series of handbooks.
** New handbook in this series; will be issued shortly.

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C3	**DC04***	**Loudspeakers**
C20	**DC05***	**Wire-wound components for TVs and monitors**

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C9	**PA07***	**Piezoelectric quartz devices**
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* Not yet issued with the new code in this series of handbooks.

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T13	**PC08**	**Image intensifiers**
T15	**PC09****	**Dry reed switches**
C8	**PC10**	**Variable mains transformers; annular fixed transformers**
	PC11	**Solid state image sensors and peripheral integrated circuits**

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** Not yet issued with the new code in this series of handbooks.

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