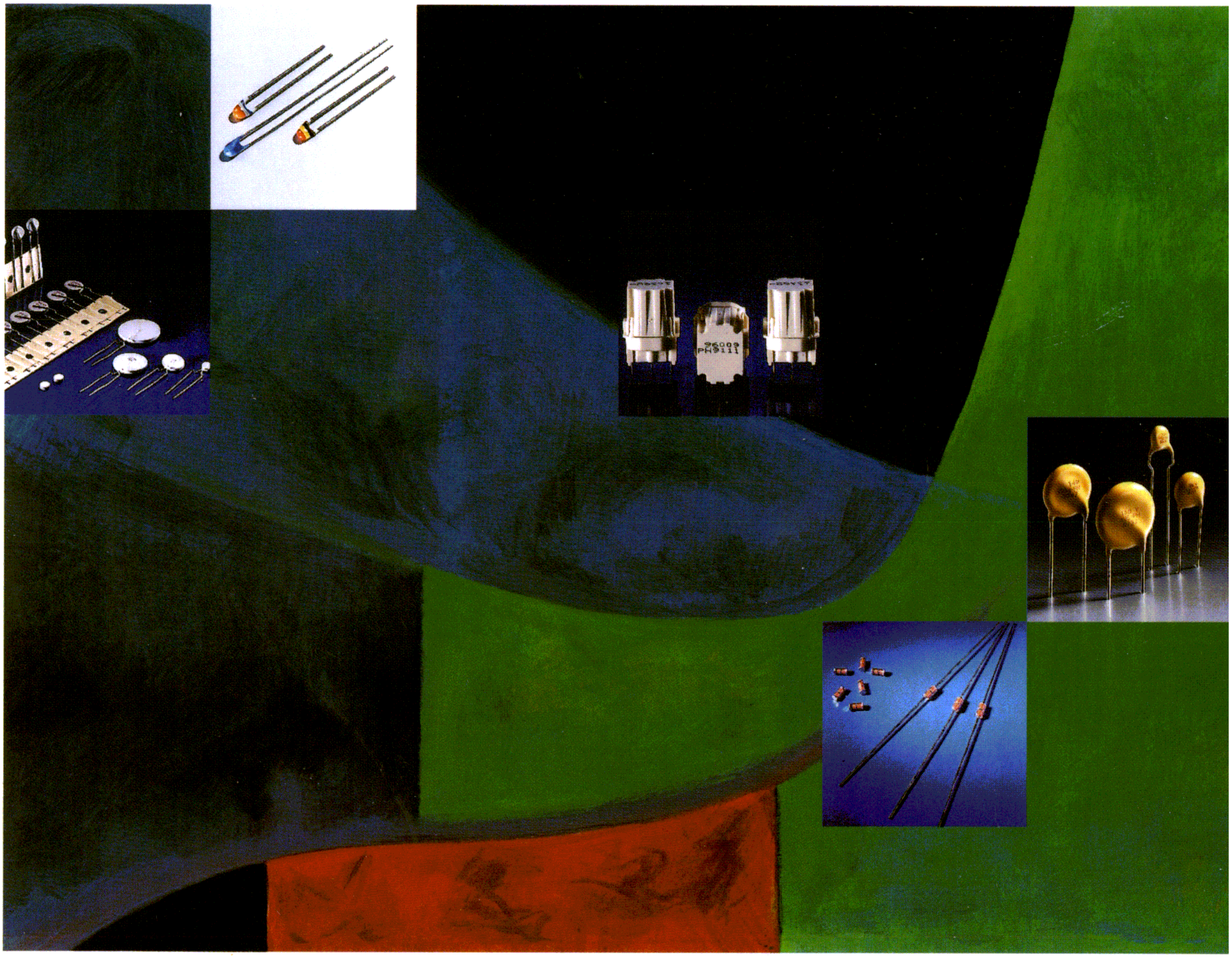
PASSIVE COMPONENTS

Varistors, Thermistors and Sensors



1995

DATA HANDBOOK PA02

Philips Components

PHILIPS

Varistors, Thermistors and Sensors

CONTENTS

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

SELECTION GUIDE

NEGATIVE TEMPERATURE COEFFICIENT (NTC) THERMISTORS

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		plastic housing	2322 662 96.24	208
		plastic housing	2322 662 96.02	208
		plastic housing	2322 662 96.13	208
	long decay	plastic housing	2322 662 96.16	208
		plastic housing	2322 662 96.26	208
	high inrush	plastic housing	2322 662 96706	208
		plastic housing	2322 662 96705	208
	mono	plastic housing	2322 662 96281	208
		plastic housing	2322 662 96682	208
		plastic housing	2322 662 96683	208
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		leaded, on tape	2322 66. 3...1	229
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		leaded, bulk	2322 66. 1...3	229
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Varistors, Thermistors and Sensors — Selection guide

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HUMIDITY SENSOR

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GENERAL INTRODUCTION

GENERAL INTRODUCTION

Varistors, Thermistors and Sensors (V, T and S) are part of our extensive range of Passive Components. We have been making these non-linear resistors for more than 20 years and gained an enviable reputation for our advanced ceramic technology, high quality and value for money solutions.

V, T and S products are used as sensing and protection devices in all kinds of electronic applications.

This data handbook contains our broad range of standard products, but our major strength is the capability to offer customized products which have to be application specific.

Product overview

DEVICE	FUNCTION	APPLICATION
PTC thermistors	degaussing	colour televisions colour monitors
	temperature protection	industrial electronics power supplies electronic data processing
	overload protection	telecommunications automotive systems industrial electronics consumer electronics electronic data processing
NTC thermistors	temperature sensing	domestic appliances automotive systems industrial electronics medical electronics
	temperature compensation	industrial electronics consumer electronics electronic data processing
Varistors (VDR)	transient suppression	telecommunications automotive systems industrial electronics consumer electronics domestic appliances electronic data processing
Humidity sensors	humidity sensing	industrial electronics domestic appliances electronic data processing

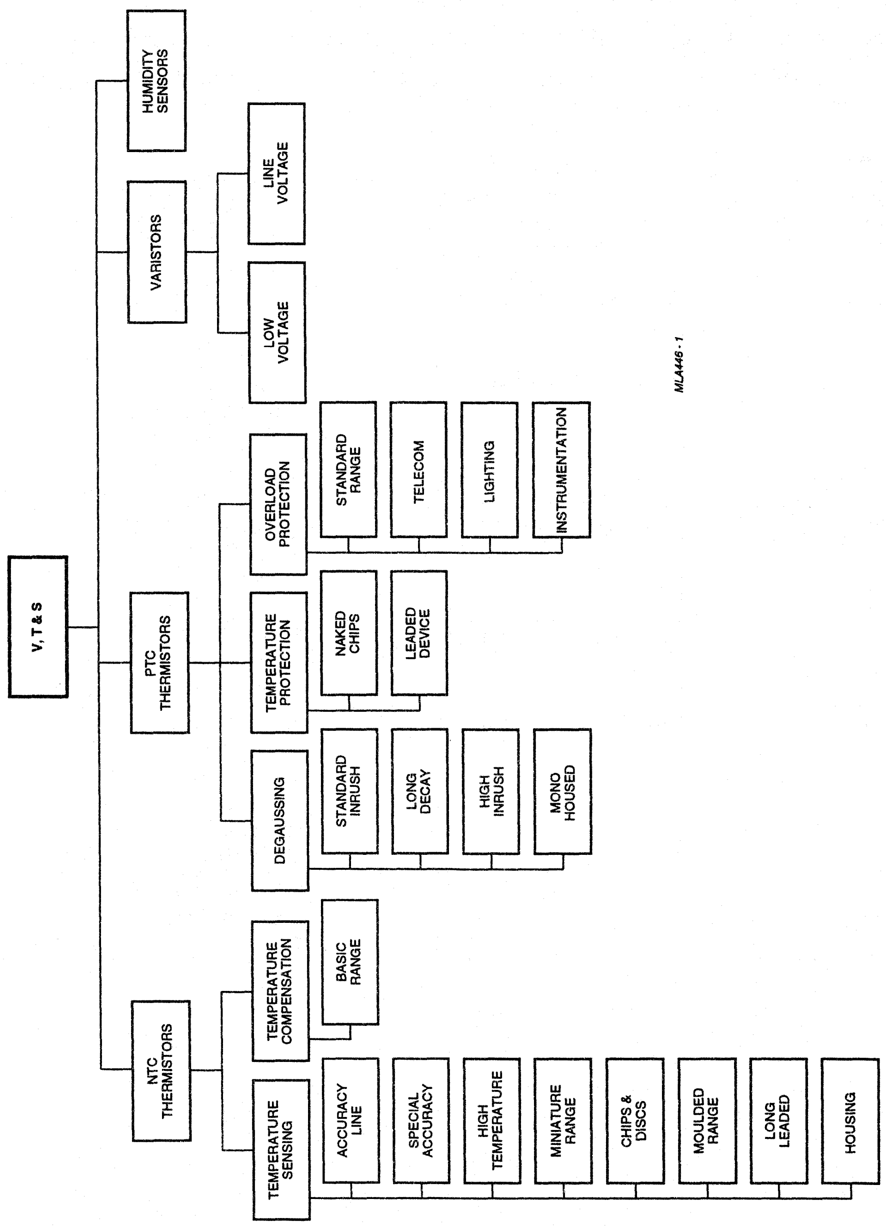


Fig.1 General introduction.

APPLICATIONS

V, T AND S APPLICATIONS

APPLICATION	PTC THERMISTORS			NTC THERMISTORS		VARISTORS	HUMISTORS
	DEGAUSSING	TEMP. PROT.	OVERLOAD PROT.	TEMP. SENSING	TEMP. COMP.	TRANSIENT PROT.	HUMIDITY SENSING
Telecommunications			X			X	
Automotive		X	X	X		X	
Small domestic appliances		X	X	X		X	X
Large domestic appliances (white goods)		X	X	X		X	
Colour televisions, monitors	X					X	
Other consumer equipment		X	X		X	X	
EDP		X	X		X	X	X
Lighting			X			X	
General industrial		X	X	X	X	X	X
Medical				X			
SMPS		X	X				

NEGATIVE TEMPERATURE COEFFICIENT (NTC) THERMISTORS

GENERAL

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 composition of which is 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. 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 the 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:

$$\sigma = n \times e \times \mu$$

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

Both n and μ are functions of temperature. For μ, the dependency 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:

$$\mu \div T^{-c} \times e^{-q_2/kT}$$

For n, the dependency on temperature can be explained as follows: 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:

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

The total temperature dependency of the conductivity is:

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

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

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

where $B = q_1 + q_2$

or

$$\log R = A + \frac{B}{T}$$

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

Shape of an NTC curve and determination of B-value

In Fig.1, the resistance is plotted as a function of the inverse of the temperature. Even in semi-logarithmic 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 for 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 can be found as follows:

The resistance value is measured at T_1 and T_2:

$$R_1 = A \times e^{B/T_1}$$

and

$$R_2 = A \times e^{B/T_2}$$

Dividing yields:

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

or

$$\log R_1 - \log R_2 = B\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\log e$$

Hence:

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

In practice, B varies slightly with increasing temperature.

The temperature coefficient of an NTC may be derived from: $\alpha = \frac{1}{R} \times \frac{dR}{dT} = -\frac{B}{T_2}$

For the different materials, the constant B may vary between 2000 and 5500 K; e.g. a value of 3600 K yields $\alpha = -4\%/K$ at a temperature of 300 K.

A and B are assumed to be constant between T_1 and T_2 $\left(B_{T_1/T_2}\right)$.

In practice, most NTCs 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.

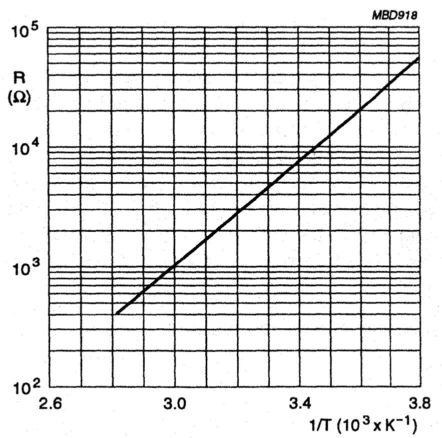


Fig.1 Resistance as a function of the inverse of temperature for a typical NTC.

Voltage (V)/Current (I)-characteristic description

Figure 2 shows the relationship between the current through and the voltage drop across 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 = f[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 the Joule-effect (P = V × I). 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 too. The characteristic shown in Fig.2 was measured at a constant ambient temperature after equilibrium had been reached.

Assuming that:

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

then, in case of equilibrium:

$$W = V \times A = \delta(T - T_0)$$

where T_0 is the ambient temperature and δ the dissipation factor (defined in Chapter "Speed of response").

From this relationship, it is obvious that the temperature of the component will be that of its surroundings if the power P (W) applied to the component is equal to zero (power-off value). If the applied power is not very low (≥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 only 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.

V/I-CHARACTERISTIC

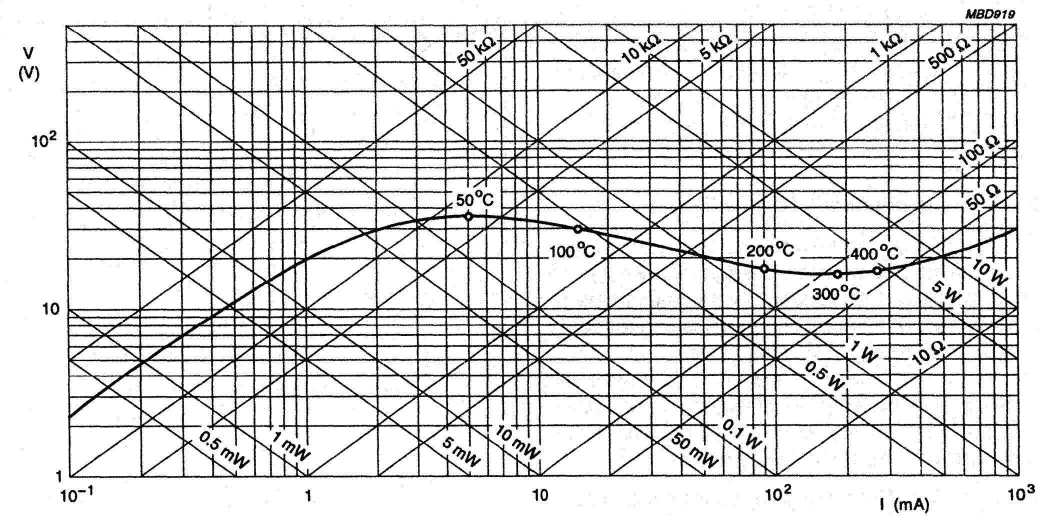


Fig.2 Voltage as a function of the current characteristics of a NTC thermistor.

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 parameter 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 loose 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 (t) is equal to τ is given by the formula:

$$T - \frac{T_0}{T_1} - T_0 = \left(1 - e^{-1}\right) = 0.632$$

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 with "*IEC 539*": 85 °C and 25 °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 depends on the application:

- By cooling in air under zero power conditions (T_c)
- By heating or cooling, transferring the thermistor from ambient temperature (25 °C) to a bath with fluid with a higher or lower temperature under zero power conditions (T_r, termed 'response time' in the data sheets).

Tolerances in 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, variations of mechanical dimensions. The entire curve moves equally up or down (see Fig.3).

This tolerance is usually indicated by giving the shift at the reference temperature; 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 (see Fig.4).

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

The fundamental equation of an NTC is:

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

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

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

$$R_T = R_{nT} + \Delta R_T = R_{ref} e^{(B+\Delta B)(1/T-1/T_{ref})}$$

where ΔR_T is the absolute deviation at temperature T:

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

If relative deviation is applied:

$$\frac{\Delta R_T}{R_{nT}} = e^{\Delta B(1/T-1/T_{ref})-1}$$

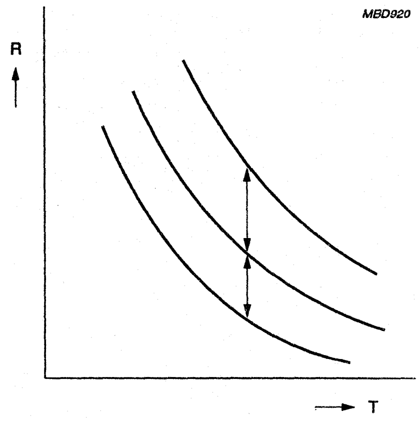


Fig.3 Effect of variations of mechanical dimensions on the resistance as a function of temperature.

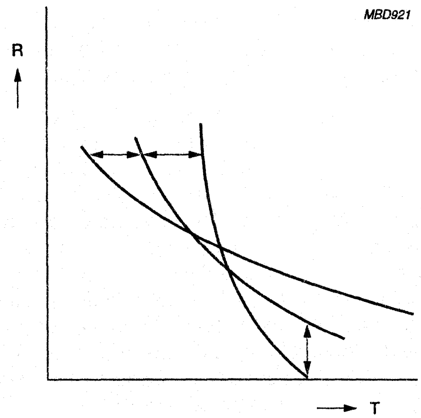


Fig.4 Effect of sintering on the resistance as a function of temperature.

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

$$\frac{\Delta R_T}{R_{nT}} \text{(in \%)} = \Delta B\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)$$

This calculation has been performed for all major sensor ranges to be found in this handbook, where 'R-deviation due to B-tolerance' values can be found in the electrical 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 follows:

$$Z = \left[\left(1 + \frac{X}{100}\right) \times \left(1 + \frac{Y}{100}\right) - 1\right] \times 100\%$$

or, after approximation:

$$Z \approx X + Y$$

If TC is the temperature coefficient and ΔT is the temperature deviation:

$$\Delta T = \frac{Z}{TC}$$

EXAMPLE

At 0 °C, assume X = 5%, Y = 0.089% and TC = 5.08%/K, then:

$$Z = \{\left(1 + \frac{5}{100}\right) \times \left(1 + \frac{0.89}{100}\right) - 1\} \times 100\%$$

or

$$Z = \{1.05 \times 1.0089 - 1\} \times 100\% = 5.9345\% \quad (\approx 5.93\%)$$

$$\Delta T = \frac{Z}{TC} = \frac{5.93}{5.08} = 1.167 \text{ °C} \quad (\approx 1.17 \text{ K})$$

Hence, an 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 measurement)

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 minimum in the temperature region between the reference points, as illustrated in Fig.5.

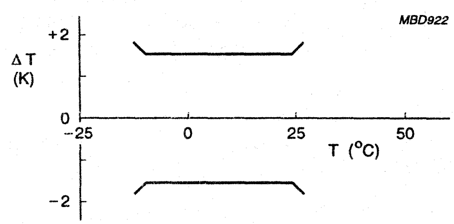


Fig.5 Temperature measurement at more than one point.

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.

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 respectively.

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.

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 the measurement at 25 °C and that 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 measurements 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 fluid 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

Selection of an NTC thermistor

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:
  - Without perceptible change in resistance value due to self-heating
  - With maximum change in resistance value
- Permissible temperature range
- Thermal time constant, if applicable
- Types best suited to the purpose. Basic forms are chip, 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 event a specification of the requirements is necessary. A description of the circuit in which the NTC is to be used, is most useful.

Deviating characteristics

The following example explains the resistance values resulting from combinations of an NTC thermistor and normal resistors.

Suppose an NTC must have a resistance of 50 Ω at 30 °C and 10 Ω at 100 °C. A standard type having this characteristic is not included in our programme. The problem may, however, be solved by using a standard NTC and two fixed resistors, e.g. an NTC disc with a cold resistance of 130 Ω mounted in a series and parallel arrangement with two fixed resistors of 6 Ω and 95 Ω respectively. 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 °C is allowed.

HOW NTC TEMPERATURE SENSORS FUNCTION

NTC temperature sensors are made from pure metal oxides. They respond quickly to temperature changes, even small temperature increases cause their resistance to decrease significantly, as shown in Fig.6.

So, by placing an NTC temperature sensor into one arm of a bridge circuit, accurate temperature measurement is possible.

The main characteristics of an NTC temperature sensor are expressed by three parameters:

- The resistance at 25 °C (R_{25}). Tolerances on the R_{25}-value are mainly caused by manufacturing and material tolerances. By using very precise sawing, tolerances on R_{25} lower than 1% (or 0.25 °C) can be achieved.
- The material constant (B). This constant relates the rate of change of resistance with temperature, and therefore affects the slope of the R/T-characteristic.

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

  where R is the resistance at absolute temperature T (in Kelvin) and A is a first-approximation constant. In practice, B is defined between two selected temperatures. The B-value is very useful for comparing sensors, but in making this comparison, care must be taken to ensure that the same two temperatures are used (normally 25 and 85 °C).

  Tolerances on B-value are mainly caused by material tolerances and by the effects of the sintering temperature on the material. Our new materials have tolerances on the B-value as low as 0.75%.
- The temperature coefficient of resistance (α), expressed in %/K. This coefficient indicates the sensitivity of the sensor to a change in temperature. Values of α are given in the *"Data sheets"* in this *"Data Handbook"*.

  For calculation purposes holds $\alpha = \frac{\Delta R}{\Delta T}$, where ΔR is the percentage change in resistance at the required temperature (see Fig.7), and ΔT is the temperature deviation (T in Kelvin). So, when ΔR and α are known for any temperature, ΔT (the temperature deviation in °C) can be calculated.

  The plot of ΔR as a function of T is known as the butterfly characteristic, which really shows how good a sensor is (see Fig.7). It shows that a typical Philips sensor is far more accurate than a similar competitor sensor. That is why we are renowned as world leaders in high-accuracy sensor technology.

Tolerance on R_{25} and the resistance tolerance due to B-value combine to affect the performance of the sensor over its operating temperature range (see Fig.8).

However, from an operational point of view, it is far better to express sensor tolerance in terms of temperature deviation ΔT over a temperature range. This plot is shown in Fig.9.

Again we have shown a typical comparison with a similar competitor sensor. Note how Philips outperforms the competitor right across the temperature range.

Two other parameters which are important in specifying NTC temperature sensors are the thermal time constant and the response time:

- The thermal time constant is the time required for the temperature of the sensor to change **in air** by $\left(1 - \frac{1}{e}\right)$ = 63.2% of the difference between its initial and final body temperatures, when subjected to a step function temperature change (85 °C to 25 °C in accordance with *"IEC 539"*).
- The response time is the time the sensor needs to reach 63.2% of the total temperature difference when subjected to a temperature change from 25 °C **in air** to 85 °C **in silicone oil** (MS 200/50).

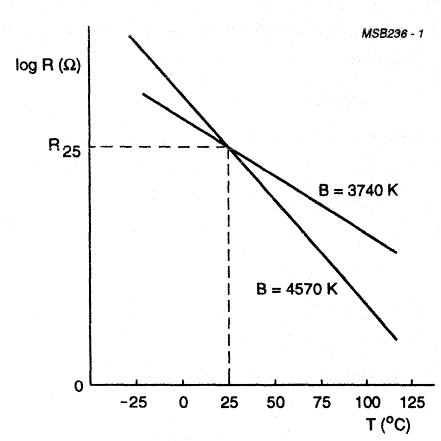


Fig.6 Typical plot of resistance as a function of temperature for an NTC temperature sensor.

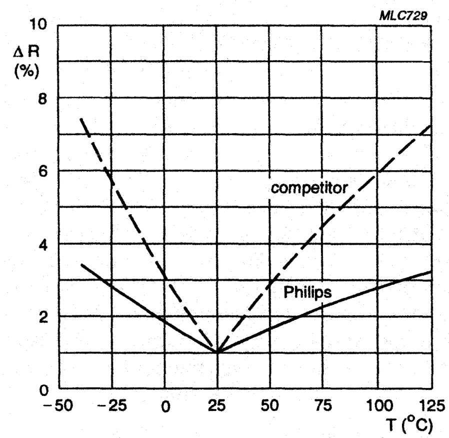


Fig.7 Typical resistance change as a function of temperature for a 1% Philips NTC temperature sensor compared to a competitor sensor.

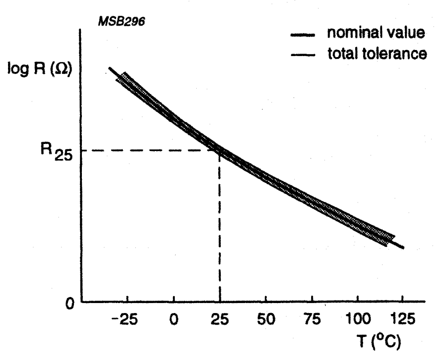


Fig.8 The combined effects of tolerance on R_{25} and resistance tolerance due to B-value.

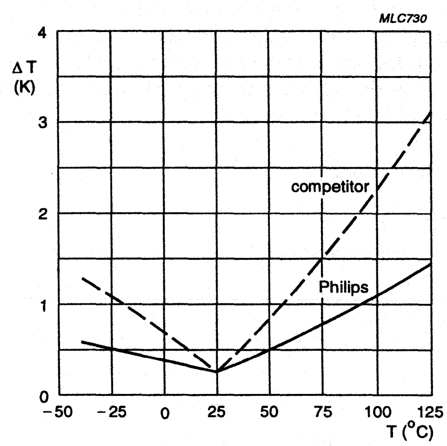


Fig.9 Temperature deviation as a function of temperature.

APPLICATIONS

General

Temperature is one of the variables that must be measured most frequently. There are as many as nineteen recognized ways of measuring it electrically, most commonly by thermocouples, platinum-bulb thermometers and NTC (Negative Temperature Coefficient) temperature sensors. For general-purpose temperature measurement, NTC temperature sensors are accurate over a wide temperature range (−55 to +300 °C). They are stable throughout a long lifetime, have a high impedance and are small and inexpensive. In fact, they are the first choice for most temperature measurements. Typically, they have a negative temperature coefficient of approximately −4.5%/K at room temperature (25 °C), more than ten times the sensitivity of a platinum-bulb thermometer of the same nominal resistance at the same temperature.

When you are aiming for accuracy, Philips has the NTC temperature sensors to help you achieving it. We have been making NTC temperature sensors for many years and we have gained an enviable reputation for our value-for-money ranges. Our component manufacturing and marketing activities are represented in more than 60 countries. This worldwide commitment ensures security of supply, guaranteed quality and technical support in every major industrial market. Recent developments in ceramics technology have allowed us to introduce sensors with resistance tolerances lower than 1% and B-value tolerances down to 0.75%. They add precision to your applications and allow you to design-in even more attractive features. And because you are dealing with Philips, you can be sure of excellent quality, design-in support and service.

Application areas

AUTOMOTIVE SYSTEMS

NTC temperature sensors are widely used in cars. For example in:

- Electronic fuel injection, in which air-inlet, air/fuel mixture and cooling water temperatures are used to determine fuel concentration for optimum injection
- Fan motor control, based on cooling water temperature
- Oil and water temperature controls
- Climatization systems, such as air-conditioning and seat temperature controls
- Frost sensors for outside temperature measurement
- Oil level indication
- ABS.

GENERAL INDUSTRIES

NTC temperature sensors are used in thermal switches, measuring systems and detectors in all segments of industry, notably the following:

- Aerospace/military
- Biomedical/health care
- Education/research
- Electronics/edp
- Energy/environmental
- Food processing
- Heating and ventilating
- Metallurgy
- Petrochemical/chemical
- Weather forecasting
- Fire and smoke detection
- Battery temperature control
- Instrumentation
- Air conditioning.

DOMESTIC APPLIANCES

NTC temperature sensors are used extensively in domestic appliances. You will find at least one NTC temperature sensor in just about anything in the home that gets cold, warm or hot, such as:

- Fridges and freezers
- Cookers and microwave ovens
- Deep-fat fryers
- Coffee makers
- Food warmers and processors
- Washing machines
- Electric irons
- Dish washers
- Electric blankets
- Hair dryers
- Smoke and heat detectors
- Central heating
- Boilers
- Air conditioning
- Aquariums
- Water beds.

APPLICATION GROUPING

Applications of NTCs 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, when 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 $V = f(I)$ characteristic shows a negative slope.

The classifications given above are supported by practical examples in Figs 10 to 23.

Examples

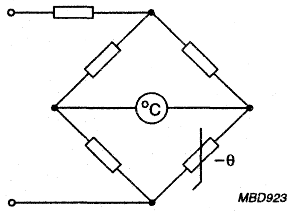


Fig.10 Temperature measurement in industrial and medical thermometers.

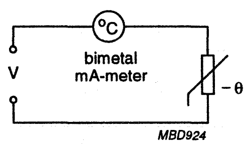


Fig.11 Car cooling water temperature measurement with bimetal.

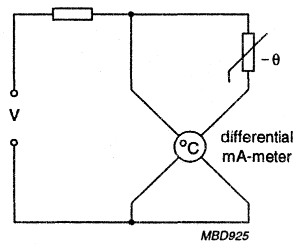


Fig.12 Car cooling water temperature measurement with differential mA-meter.

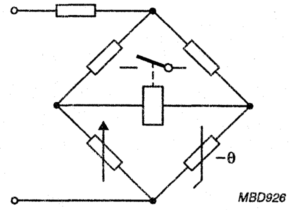


Fig.13 Temperature measurement with a bridge incorporating an NTC thermistor and a relay or a static switching device.

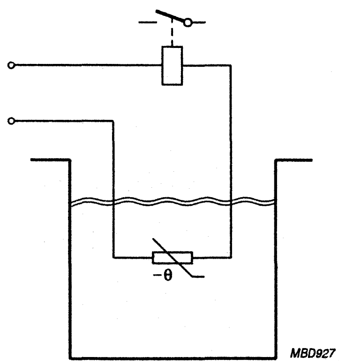


Fig.14 Liquid level control.

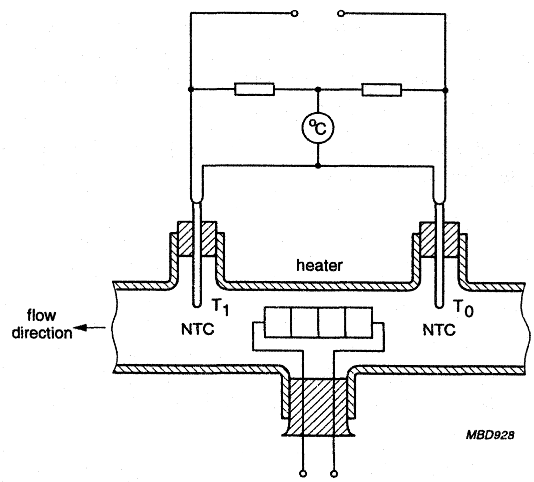


Fig.15 Flow measurement of liquids and gases. The temperature difference between T_1 and T_0 is measured for the velocity of the fluid.

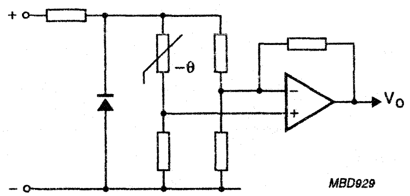


Fig.16 Temperature sensing bridge with op-amp which acts as differential amplifier. The sensitivity can be very high.

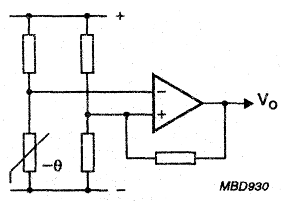


Fig.17 Basic temperature sensing configuration. The op-amp (e.g. NE532) acts as a Schmitt-trigger. The transfer characteristic is shown in Fig.18.

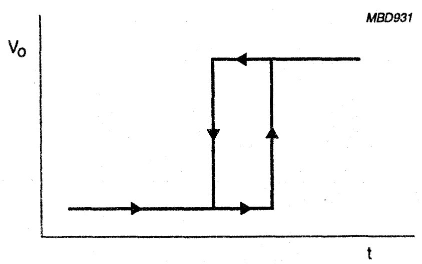


Fig.18 Transfer characteristic of the circuit shown in Fig.17.

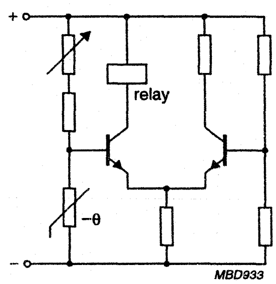


Fig.19 Simple thermostat.

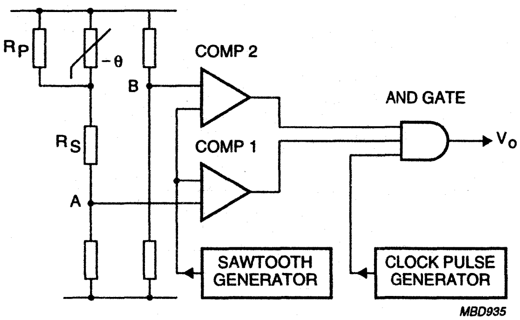


Fig.20 Temperature sensing bridge with 0 °C offset and ADC. Due to R_P and R_S the voltage at A varies linearly with the NTC thermistor temperature. The voltage at B is equal to that at A when the NTC thermistor temperature is 0 °C. Both voltages are fed to the comparator circuit. See also Fig.21.

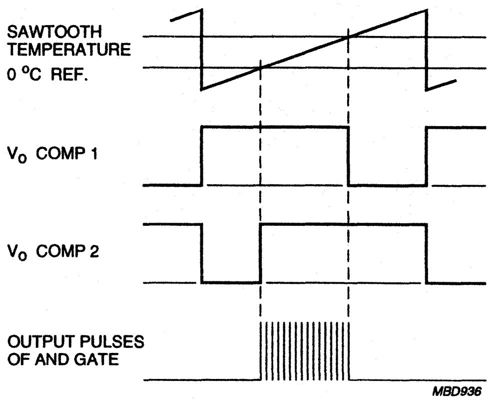


Fig.21 Pulses occurring at various points in the circuit shown in Fig.20.

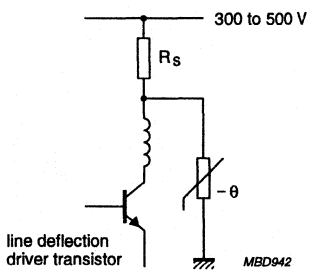


Fig.22 Constant current circuit (sure start-up) for line deflection stage.

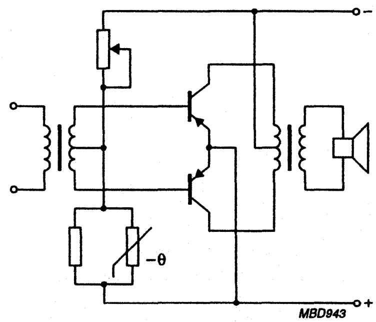


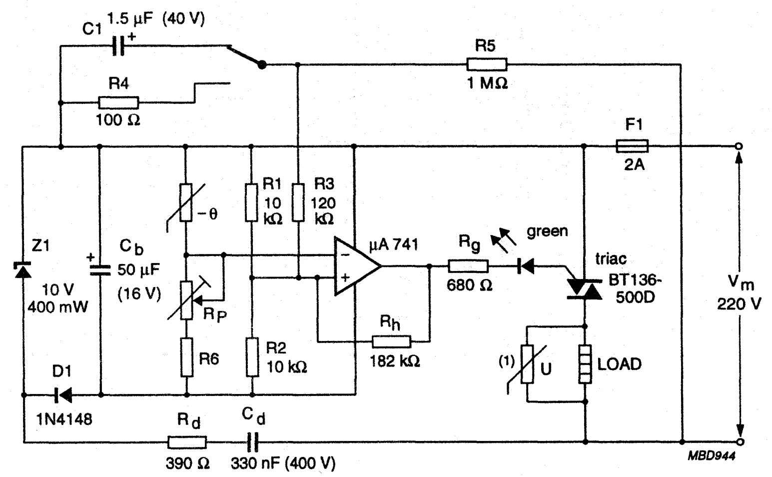
Fig.23 Temperature compensation in transistor circuits. Push-pull compensation.

NTC temperature sensors used as a thermal switch

A common use of an NTC temperature sensor is in one of the bridge arms of a thermal switch circuit using an operational amplifier such as the µA741. Figure 24 shows a typical thermal switch circuit for a refrigerator thermostat.

The circuit consists of a 10 V (DC) zener diode stabilized power supply, a Wheatstone Bridge (containing the NTC temperature sensor) and an integrated comparator circuit controlling a triac. The circuit is designed to switch a maximum load current of 2 A off at –5 °C and on at +5 °C.

TEMPERATURE SENSING IN REFRIGERATORS



(1) Catalogue number: 2322 593 32312.
All resistors are 0.25 W.

Fig.24 Refrigerator thermostat using an NTC temperature sensor.

HEAT DETECTION IN FIRE ALARMS

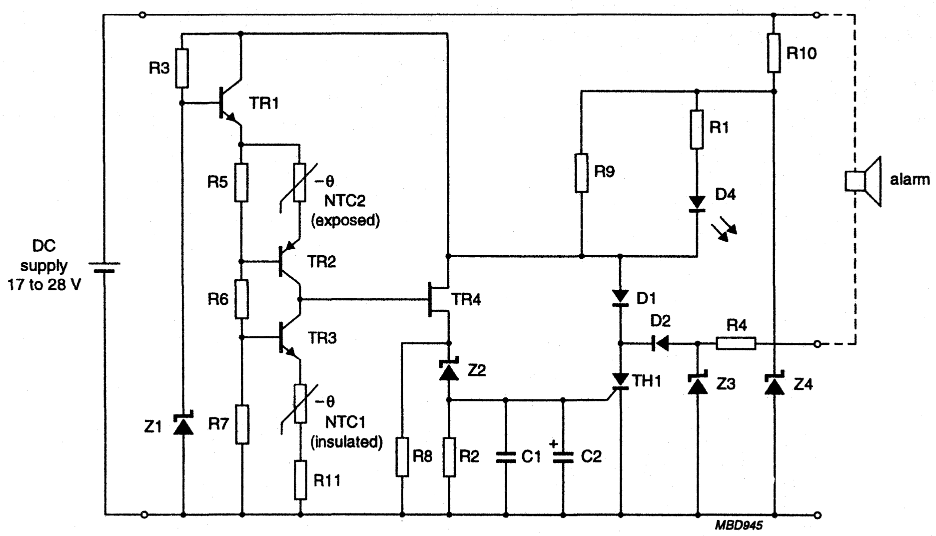


Fig.25 Circuit diagram of a typical heat detector using a matched pair of NTC thermistors.

NTC temperature protection of rechargeable batteries

Figure 26 shows the circuit diagram of an 'intelligent' charger designed to charge, within 1 hour, a NiCd or NiMH battery pack containing up to six AA-type cells. The TEA110X allows any type of power regulator to be used. In Fig.26, the unregulated 12 V (DC) supply is passed through a linear power regulator to charge the batteries under the control and management of the TEA110X. The BYD13D diode inhibits further charge (and prevents discharge) when the battery pack is full. For further information refer to *"Application Note NTC temperature protection of rechargeable batteries, code number 9398 082 91011"*.

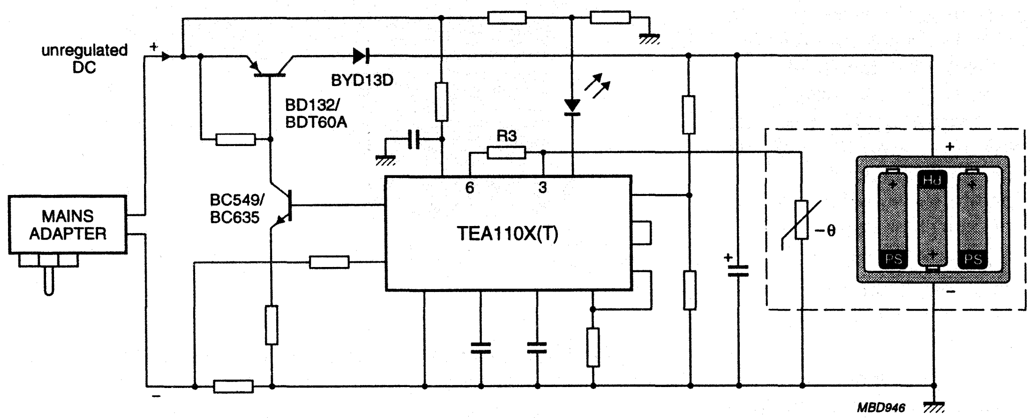


Fig.26 'Intelligent' charger based on the TEA110X with NTC battery temperature sensing.

SELECTING A SENSOR

Use the following steps in the specified order to select the required sensor:

1. What temperature range is required? Refer to Fig.27.
2. What R_{25} is required? Refer to the *"Data sheets"* in this *"Data Handbook"*.

   This *"Data Handbook"* gives the resistance/temperature characteristics for each sensor. In practice, the circuit surrounding the sensor will determine the required resistance at room temperature (R_{25}). This value will usually be between 10 and 20 kΩ for the optimum operating temperature range of the sensor. Simply select the sensor having the most suitable R_{25} value.
3. Are there any other important parameters? Refer to Tables 1 and 2.
4. Can you fulfil your need from our standard ranges (particularly from the Accuracy Line, see Table 1) or do you need a special accuracy (calculation) or encapsulation?

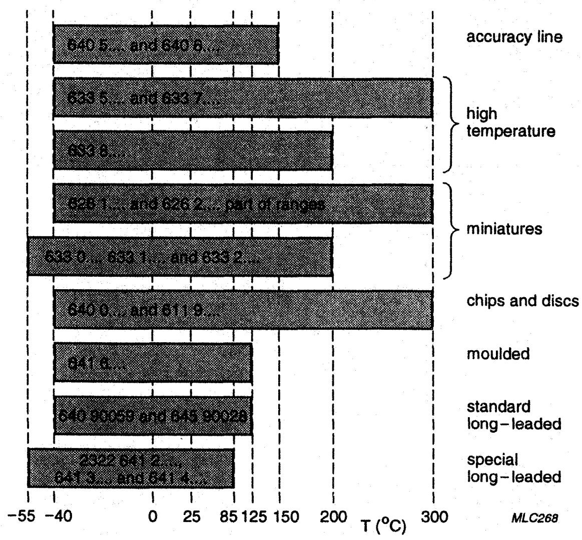


Fig.27 Temperature selection chart for the standard NTC temperature sensor ranges.

Table 1 Parameter selection chart

PARAMETER	ACCURACY LINE 2322				HIGH-TEMPERATURE SENSORS 2322			MINIATURE SENSORS 2322				UNIT
	640 5....	640 6....	645 0....	642 6....	633 5....	633 7....	633 8....	626 1....	626 2....	633 0.... 633 1....	633 2....	
R_{25}	2.2 to 470	0.47 to 470	5 to 10	0.0033 to 1.5	10, 20, 30, 100	100, 220	10, 20, 30, 100	1 to 1000	1 to 1000	1 to 1000	1 to 1000	kΩ
Tolerance on R_{25}	1, 2, 3, 5	2, 3, 5, 10	5	5, 10	5, 10	5, 10	5, 10	5, 10	5, 10	5, 10	5, 10	%
B-value	3740 to 4570	3740 to 4570	3965	2675 to 3975	3977	3977	3977	2075 to 4100	2075 to 4100	2075 to 4100	2075 to 4100	K
Tolerance on B-value	0.75 to 2.5	0.75 to 2.5	±0.75	–	1.3	1.3	1.3	5	5	5	5	%
Max. body diameter	3.4	3.3 ±0.5	3.3 ±0.5	5 ±0.3	1.7	1.85	1.85	2.5	1.6	0.7 to 1	3	mm
Lead diameter	0.4	0.6	0.6	0.6	–	0.56	0.56	0.3	0.24	0.06	0.24	mm
Min. lead length	38	17	17	22 ±1	–	25.4	25.4	30	19	5	20	mm

Table 2 Parameter selection chart (continued)

PARAMETER	CHIPS AND DISCS 2322		MOULDED SENSORS 2322	STANDARD LONG-LEADED SENSORS 2322		SPECIAL LONG-LEADED SENSORS 2322			UNIT
	640 0....	611 9....	641 6....	640 90059 (insulated)	645 90028 (non-insulated)	641 2.... (epoxy)	641 3.... (water-resistant)	641 4.... (pipe)	
R_{25}	2.2 to 470	2.2 to 470	2.2 to 470	2.77	10	2.2 to 470	2.2 to 470	2.2 to 470	kΩ
Tolerance on R_{25}	1, 2, 3, 5	–	3	3.82	5	3	3	3	%
B-value	3740 to 4570	3500 to 4093	3740 to 4570	3977	3993	3740 to 4570	3740 to 4570	3740 to 4570	K
Tolerance on B-value	0.75 to 2.5	–	0.75 to 2.5	–	1, 2	0.75 to 2.5	0.75 to 2.5	0.75 to 2.5	%
Max. body diameter	2.7	5.2	4 ±0.2	2.5 to 2.6	2.5 to 2.6	6	6	6	mm
Lead diameter	–	–	0.6	0.58	0.3	–	–	–	mm
Min. lead length	–	–	21 ±1	110 ±5	110 ±5	400 ±10	400 ±10	400 ±10	mm

Examples

To illustrate the method of selecting an NTC temperature sensor for your application, consider the following two examples, applying the selection procedure.

EXAMPLE 1

A sensor is required to measure temperatures from 0 to 100 °C with an accuracy of ±3 °C:

1. Step 1 (temperature range)

   Figure 27 shows that all our sensors will operate over the temperature range from 0 to 100 °C.

2. Step 2 (R_{25} value) and Step 3 (other important parameters)

   The sensor will normally be connected into an arm of a bridge. The resistance of the other arms of the bridge will determine the approximate 'cold' resistance value R_{25}. Let us assume that the resistance is 4.7 kΩ and that there are no other critical parameters (response time, etc.).

3. Step 4 (can you fulfil your need from our standard ranges?)

   Our range of low-cost Accuracy line sensors 2322 640 5.... and 640 6.... should be checked first, referring to Tables 1 and 2. From the data sheets you will find that the 2322 640 6.472 and the 640 5.472 may be suitable and that they are available with a 2%, 3%, 5% and 10% or a 1%, 2% and 3% tolerance on R_{25}.

From the equation $\alpha = \frac{\Delta R}{\Delta T}$ you can calculate ΔT. But since α depends on temperature, you need to know the temperature coefficients α_0 and α_{100}.

In this *"Data Handbook"* you will find that $\alpha_0 = -5.08\%/K$ and $\alpha_{100} = -2.94\%/K$. In addition, you can find that the resistance tolerance due to the B-value is 0.89% at 0 °C and 2.04% at 100 °C.

So, the ±3 °C accuracy on temperature imposes a maximum allowable resistance variation at 0 °C of $\Delta R_0 = \alpha_0 \times \Delta T = -5.08 \times \pm3 = \pm15.24\%$ (of nominal resistance at 0 °C).

Similarly, the maximum allowable resistance variation at 100 °C is $\alpha_{100} \times \Delta T = -2.94 \times \pm3 = \pm8.82\%$ (of nominal resistance at 100 °C).

The actual resistance tolerance of the sensor is the sum of two components:

- The tolerance on the R_{25}-value
- The resistance tolerance due to the B-value (being zero at 25 °C but increasing at temperatures other than 25 °C).

Considering the lower-cost 5% tolerance sensor first: at 0 °C the worst case tolerance is 5% + 0.89% = 5.89%, which is well within the 15.24% imposed by the temperature tolerance. And at 100 °C the worst case tolerance is 5% + 2.04% = 7.04%, which again is well within the 8.82% requirement.

So, assuming that no special encapsulation is required, the 2322 640 63472 sensor fulfils the requirements.

EXAMPLE 2

A sensor is required to measure temperatures from 0 to 250 °C. It must be able to measure at 25 °C with an accuracy of ±2 °C. Its R_{25} value must be 10 kΩ and it must have a radial lead configuration and a minimum body length of 25 mm for encapsulation in a special housing:

1. Step 1 (temperature range)

   The high-temperature requirement (see Fig.27) restricts the choice of leaded sensors to 2322 626 1.... or 626 2.... or 633 8.... sensors.

2. Step 2 (R_{25}-value) and Step 3 (other important parameters)

   R_{25} = 10 kΩ is available for the 2322 626 1...., 626 2.... and 633 8.... ranges. All types have radial lead configurations, but body length dictates the selection of the 2322 626 1.... range, and in particular the 2322 626 1.103 sensor.

3. Step 4 (can you fulfil your need from our standard ranges?)

   The calculation of tolerance is: ±2 °C accuracy imposes a maximum resistance tolerance at 25 °C of $\alpha_{25} \times \Delta T$.

For the 2322 626 1.103 sensor it holds that the maximum resistance tolerance is $4.2 \times 2 = 8.4\%$ ($\alpha_{25} = 4.2$). So the 5% sensor 2322 626 13103 will satisfy the requirement.

RANGE SUMMARY

- **Accuracy Line**
  - 2322 640 5.... and 640 6....

    The flagship of our ranges. The Accuracy Line sensors offer real value for money. They have low tolerances (as low as ±1% on the R_{25}-value and ±0.75% on the B-value) and an operating temperature range from −40 to +150 °C. In addition, they are very stable over a long life.
  - 2322 645 ..... series

    This range is our American standard line with an excellent accuracy over a wide temperature range (±0.75% on the B-value). R_{25}-values are available from 5 kΩ to 10 kΩ with an operating temperature range from −40 to +150 °C.
  - 2322 642 6.... series

    This range is mainly used for compensation purposes with R_{25}-values between 3.3 Ω and 1.5 kΩ.
- **High-temperature sensors**
  - 2322 633 5...., 633 7.... and 633 8....

    This range of high-quality glass-encapsulated NTC temperature sensors are price-competitive for general use. Not only can these sensors be used at up to 300 °C, but their glass encapsulation makes them ideal for use in corrosive atmospheres and harsh environments, even down to −40 °C. This makes them an attractive alternative to other more expensive sensing methods. In addition, they are very small. Two types of tiny glass envelopes are available: SOD27 for sensors with leads, and SOD80 (the so-called MELF execution) for leadless, surface-mount sensors.
- **Miniature sensors**
  - 2322 626 ..... and 633 .....

    These ranges pack extremely high performance in very small size. And they are fast and stable in the temperature range from as low as −55 °C to as high as +300 °C.
- **Chips and discs**
  - 2322 640 0.... and 611 9....

    When leaded components cannot be used, there is always the possibility of mechanical fixing. For this purpose we supply metallized square chips with R_{25}-values from 2.2 to 470 kΩ and five types of circular disc sensors
- **Moulded sensors**
  - 2322 641 6....

    Designed for harsh environments, our moulded sensors are ideal where good surface contact is essential. The range has recently been enhanced, and can be extended further on customer request, based on the 2322 640 0.... series.
- **Standard long-leaded sensors**
  - 2322 640 90059 and 645 90028

    These sensors combine the features of the Accuracy Line with long non-insulated or insulated leads for remote sensing applications. On request these sensors can be customized, based on the 2322 640 0.... range.
- **Special long-leaded sensors**
  - 2322 641 2...., 3.... and 4.....

    For special applications we can supply three types of long-leaded sensors: water-resistant sensors for permanent immersion in water, pipe sensors for use in corrosive atmospheres and epoxy-coated sensors for general use.

PREFERRED TYPES

NTC thermistors for temperature sensing

For specific details refer to the relevant section in this data handbook.

CATALOGUE NUMBER 2322	R_{25} (kΩ)	NOMINAL B-VALUE (K)
2322 640 6.... 5% tolerance		
63222	2.2	3977 ±0.75%
63332	3.3	3977 ±0.75%
63472	4.7	3977 ±0.75%
63682	6.8	3977 ±0.75%
63103	10	3977 ±0.75%
63153	15	3740 ±2%
63223	22	3740 ±2%
63333	33	4090 ±1.5%
63473	47	4090 ±1.5%
63683	68	4190 ±1.5%
63104	100	4190 ±1.5%
63154	150	4370 ±2.5%
63224	220	4370 ±2.5%
63474	470	4570 ±1.5%
2322 640 6.... 3% tolerance		
66272	2.7	3977 ±0.75%
66472	4.7	3977 ±0.75%
66103	10	3977 ±0.75%
66473	47	4090 ±1.5%
66104	100	4190 ±1.5%
66474	470	4570 ±1.5%
2322 640 5.... 2% tolerance		
54103	10	3977 ±0.75%
54473	47	4090 ±1.5%
54104	100	4190 ±1.5%
2322 640 5.... 1% tolerance		
55103	10	3977 ±0.75%
55473	47	4090 ±1.5%
55104	100	4190 ±1.5%

CATALOGUE NUMBER 2322	R_{25} (kΩ)	NOMINAL B-VALUE (K)
2322 642 6.... 10% tolerance		
62338	3.3	2675
62478	4.7	2750
62229	22	3025
62339	33	3100
62479	47	3150
62101	100	3300
62151	150	3375
62221	220	3475
62471	470	3650
62681	680	3725
62102	1000	3825
62152	1500	3975
2322 633 5..../7..../8.... 5% tolerance		
SMD VERSION		
53103	10	–
53203	20	–
53303	30	–
LEADED VERSION		
73104; nickel-plated	100	–
83103; tinned-coppper	10	–
83203; tinned-coppper	20	–
83303; tinned-coppper	30	–
83104; tinned-coppper	100	–
2322 641 6.... moulded		
66272	2.7 kΩ ±3%	3977 K ±0.75%
66123	12 kΩ ±3%	3740 K ±2%
66153	15 kΩ ±3%	3740 K ±2%
66223	22 kΩ ±3%	3740 K ±2%
66104	100 kΩ ±3%	4190 K ±1.5%
66474	470 kΩ ±3%	4190 K ±1.5%

NTC thermistors for temperature sensing (continued)

CATALOGUE NUMBER 2322 641			R_{25} (kΩ)	$B_{25/85}$-VALUE (K)
EPOXY-COATED TYPE	WATER-RESISTANT TYPE	BRASS-PIPE TYPE		
26222	36222	46222	2.2 kΩ ±3%	3977 K ±0.75%
26502	36502	–	5 kΩ ±3%	3977 K ±0.75%
26103	36103	46103	10 kΩ ±3%	3977 K ±0.75%
26473	36473	–	47 kΩ ±3%	4090 K ±2%
26104	36104	46104	100 kΩ ±3%	4190 K ±1.5%

NTC thermistors, accuracy line 2322 640 5....

FEATURES

- Accurate over a wide temperature range (tolerance on B-value between 2.5% and 0.75%)
- Good stability over a long life
- Excellent price/performance ratio
- Flexible leads
- Low heat conductivity through 0.4 mm diameter Ni-leads.

APPLICATION

Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned Ni-leads. The device is colour coded.

PACKAGING

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

MECHANICAL DATA

Marking

The thermistors are marked with coloured bands; see Fig.1 and Table 1.

Mounting

By soldering in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C	2.7 to 470	kΩ
Tolerance on R_{25}-value	±5; ±3; ±2; ±1	%
Tolerance on $B_{25/85}$-value	±2.5 to ±0.75	%
Maximum dissipation	100	mW
Response time (for information only)	1.7	s
Operating temperature range:		
at zero dissipation (continuously)	−40 to +125	°C
at zero dissipation (for short periods)	≤150	°C
at maximum dissipation (100 mW)	0 to +55	°C
Climatic category	40/125/56	
Mass	≈0.11	g

Outline

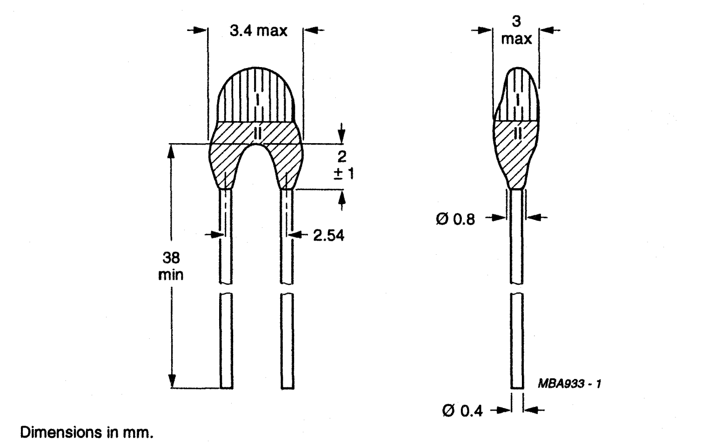


Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	VALUE	UNIT
Standard selection tolerance on R_{25}	±5; ±3; ±2 and ±1	%
Stability in accordance with *"CECC 43000"* and *"IEC 68-2"*	see Table 2	
Climatic category	40/125/56	
Maximum dissipation	100	mW
Dissipation factors δ (for information only)	2.2	mW/K
Response time (for information only); note 1	1.7	s
Thermal time constant τ (for information only)	13	s
Operating temperature range (see Fig.2):		
at zero dissipation (continuously)	−40 to +125	°C
at zero dissipation (for short periods); note 2	≤150	°C
at maximum dissipation	0 to +55	°C

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 from 25 °C in air to 85 °C in oil.
2. Valid for all types with the exception of 2322 640 5.474.

Table 1 R_{25}-values, catalogue numbers and coding; note 1

The thermistors have a 12-digit catalogue number starting with 2322 640 5. The subsequent 4 digits indicate the resistance value and tolerance.

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 640 5....				CODING (see Fig.1)	
		R_{25} ±5%	R_{25} ±3%	R_{25} ±2%	R_{25} ±1%	I	II
2.7	3977 K ±0.75%	3272	6272	4272	5272	red	red
4.7	3977 K ±0.75%	3472	6472	4472	5472	green	green
10	3977 K ±0.75%	3103	6103	4103	5103	blue	blue
47	4090 K ±1.5%	3473	6473	4473	5473	black	black
68	4190 K ±1.5%	3683	6683	4683	–	grey	grey
100	4190 K ±1.5%	3104	6104	4104	5104	brown	brown
470	4570 K ±1.5%	3474	6474	4474	–	violet	violet

Note

1. Extended range available on request.

Derating

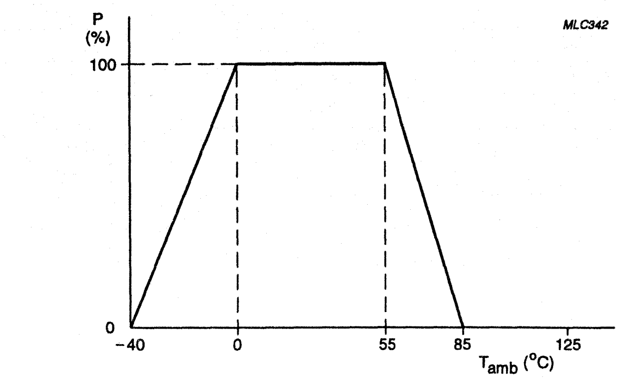
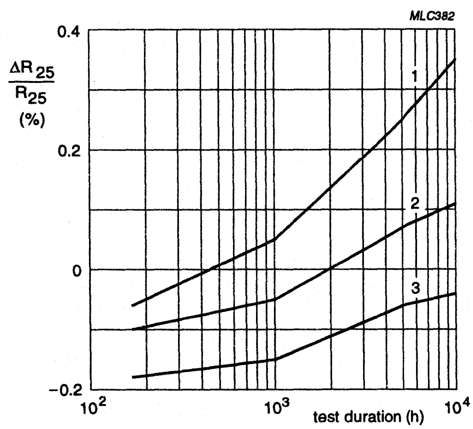


Fig.2 Power derating curve.

R_T-values and tolerance on R_T-values

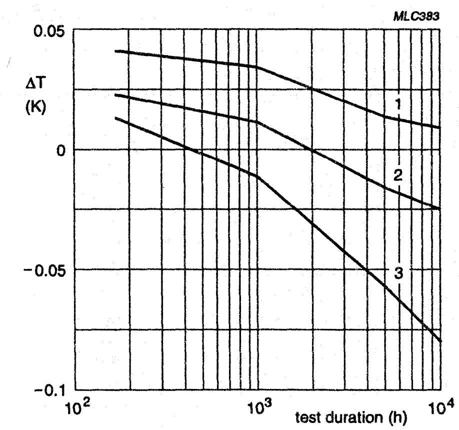
These thermistors have a narrow tolerance on the B-value, the result of which provides a very small tolerance on the nominal resistance value over a wide temperature range. The same table describing R as a function of T with steps of 5 °C as published in the data sheet for the *"2322 640 6.... series"* of thermistors is relevant here. Also, the extended *"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.

Long term stability



Curves valid for 2.2 to 10 kΩ.
Curve 1: maximum deviation.
Curve 2: average deviation.
Curve 3: minimum deviation.

Fig.3 Long term stability of R_{25} as a function of test duration at maximum temperature (150 °C).



Curves valid for 2.2 to 10 kΩ.
Curve 1: minimum deviation.
Curve 2: average deviation.
Curve 3: maximum deviation.

Fig.4 Long term stability of T as a function of test duration at maximum temperature (150 °C).

NTC thermistors, accuracy line | 2322 640 6....

FEATURES

- Accuracy over a wide temperature range
- High stability over a long life
- Excellent price/performance ratio.

APPLICATION

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned solid copper-plated leads. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Marking

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

Mounting

By soldering in any position.

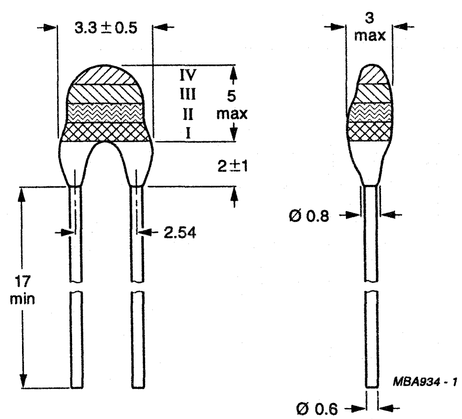
QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C	2.2 to 470	kΩ
Tolerance on R_{25}-value	±2; ±3; ±5; ±10	%
Tolerance on $B_{25/85}$-value	2.5 to 0.75	%
Maximum dissipation	500	mW
Response time	1.2	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 1	≤150	°C
at maximum dissipation (500 mW)	0 to 55	°C
Climatic category	40/125/56	
Mass	≈0.22	g

Note

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

Outline



Dimensions in mm.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*, see also Table 1.
Stability is in accordance with *"CECC 43 000"* and *"IEC 68-2"*, see Table 12.

PARAMETER	VALUE	UNIT
Standard selection tolerance on R_{25}	±2; ±3; ±5 and ±10	%
Climatic category	40/125/56	
Maximum dissipation	500	mW
Dissipation factor δ (for information only)	7	mW/K
Response time (for information only); note 1	1.2	s
Thermal time constant τ (for information only)	11	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 2	≤150	°C
at maximum dissipation	0 to +55	°C

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 from 25 °C in air to 85 °C in oil.
2. For part of product range only, see Table 1.

Derating

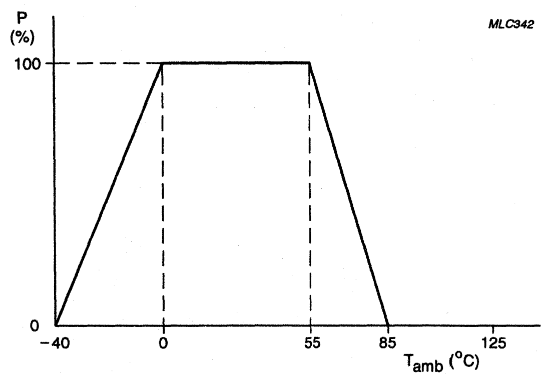


Fig.2 Power derating curve.

Table 1 R_{25}-values, catalogue numbers and coding; note 1

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 640 6....				COLOUR CODE (see Fig.1 and note 2)		
		R_{25} ±2%	R_{25} ±3%	R_{25} ±5%	R_{25} ±10%	I	II	III
2.2	3977 K ±0.75%	4222	6222	3222	2222	red	red	red
2.7	3977 K ±0.75%	4272	6272	3272	2272	red	violet	red
3.3	3977 K ±0.75%	4332	6332	3332	2332	orange	orange	red
4.7	3977 K ±0.75%	4472	6472	3472	2472	yellow	violet	red
6.8	3977 K ±0.75%	4682	6682	3682	2682	blue	grey	red
10	3977 K ±0.75%	4103	6103	3101	2103	brown	black	orange
12	3740 K ±2%	4123	6123	3123	2123	brown	red	orange
15	3740 K ±2%	4153	6153	3153	2153	brown	green	orange
22	3740 K ±2%	4223	6223	3223	2223	red	red	orange
33	4090 K ±1.5%	4333	6333	3333	2333	orange	orange	orange
47	4090 K ±1.5%	4473	6473	3473	2473	yellow	violet	orange
68	4190 K ±1.5%	4683	6683	3683	2683	blue	grey	orange
100	4190 K ±1.5%	4104	6104	3104	2104	brown	black	yellow
150	4370 K ±2.5%	4154	6154	3154	2154	brown	green	yellow
220	4370 K ±2.5%	4224	6224	3224	2224	red	red	yellow
330	4570 K ±1.5%	4334	6334	3334	2334	orange	orange	yellow
470	4570 K ±1.5%	4474	6474	3474	2474	yellow	violet	yellow

Notes

1. Maximum operating temperature range at zero dissipation is 150 °C.
2. Dependent upon R_{25}-tolerance, the band IV is coloured as follows:
   a) for R_{25} ±2%; band IV is coloured red
   b) for R_{25} ±3%; band IV is coloured orange
   c) for R_{25} ±5%; band IV is coloured gold
   d) for R_{25} ±10%; band IV is coloured silver.

R_T value and tolerance

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 Tables 3, 4, 5, 6, 7 and 8, together with a formula to calculate the characteristics with a high precision.

Formulae to determine nominal resistance values(1)

The resistance values at intermediate temperatures, or the operating temperature values, can be calculated using the following interpolation laws (extended *"Steinhart and Hart"*):

$$R(T) = R_{ref} \times e^{A + B/T + C/T^2 + D/T^3} \quad (1)$$

$$T(R) = \left(A_1 + B_1 \ln\frac{R}{R_{ref}} + C_1 \ln^2\frac{R}{R_{ref}} + D_1 \ln^3\frac{R}{R_{ref}}\right)^{-1} \quad (2)$$

where:

A, B, C, D, A_1, B_1, C_1 and D_1 are constant values depending on the material concerned; see Table 2.

R_{ref} is the resistance value at a reference temperature (in this event 25 °C)

T is the temperature in K.

(1) Formulae numbered (1) and (2) are interchangeable with an error of max. 0.005 °C in the range 25 °C to 125 °C and max. 0.015 °C in the range −40 °C to 25 °C.

Determination of the resistance/temperature deviation from nominal value

The total resistance deviation is obtained by combining the 'R_{25}-tolerance' and the 'resistance deviation due to B-tolerance'.

When:

X = R_{25}-tolerance

Y = resistance deviation due to B-tolerance

Z = complete resistance deviation,

then: $Z = \left[\left(1 + \frac{X}{100}\right) \times \left(1 + \frac{Y}{100}\right) - 1\right] \times 100\%$

or $Z \approx X + Y$.

When:

TC = temperature coefficient

ΔT = temperature deviation,

then: $\Delta T = \frac{Z}{TC}$

The temperature tolerances are plotted in Figs 3, 4, 5, 6, 7 and 8.

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

$$Z = \left\{\left[1 + \frac{5}{100}\right] \times \left[1 + \frac{0.89}{100}\right] - 1\right\} \times 100\%$$

$$= \{1.05 \times 1.0089 - 1\} \times 100\% = 5.9345\% \ (\approx 5.93\%)$$

$$\Delta T = \frac{Z}{TC} = \frac{5.93}{5.08} = 1.167\ °C \ (\approx 1.17\ °C)$$

A NTC with a R_{25}-value of 10 kΩ has a value of 32.51 kΩ between −1.17 and +1.17 °C.

Table 2 Parameters for determining nominal resistance values

$B_{25/85}$-VALUE (K)	A	B (K)	C (K^2)	D (K^3)	$A_1 \times 10^{-3}$	$B_1 \times 10^{-4}$ (K)	$C_1 \times 10^{-6}$ (K^2)	$D_1 \times 10^{-7}$ (K^3)
3740	−13.8973	4557.725	−98275	−7522357	3.353832	2.744032	3.666944	1.375492
3977	−14.6337	4791.842	−115334	−3730535	3.353832	2.569355	2.626311	0.675278
4090	−15.5322	5229.973	−160451	−5414091	3.353832	2.519107	3.510939	1.105179
4190	−16.0349	5459.339	−191141	−3328322	3.353832	2.460382	3.405377	1.034240
4370	−16.8717	5759.150	−194267	−6869149	3.353832	2.367720	3.585140	1.255349
4570	−17.6439	6022.726	−203157	−7183526	3.353832	2.264097	3.278184	1.097628

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 8, note 1					
				6.222	6.272	6.332	6.472	6.682	6.103
−40	33.21	2.66	6.57	73.06	89.67	109.6	156.1	225.8	332.1
−35	23.99	2.41	6.36	52.78	64.77	79.17	112.8	163.1	240.0
−30	17.52	2.17	6.15	38.55	47.31	57.82	82.35	119.1	175.2
−25	12.93	1.94	5.95	28.44	34.91	42.67	60.77	87.92	129.3
−20	9.636	1.71	5.76	21.20	26.02	31.80	45.30	65.53	96.36
−15	7.250	1.50	5.58	15.95	19.58	23.93	34.08	49.30	72.50
−10	5.505	1.29	5.40	12.11	14.86	18.16	25.87	37.43	55.05
−5	4.216	1.08	5.24	9.275	11.38	13.91	19.81	28.67	42.16
0	3.255	0.89	5.08	7.162	8.790	10.74	15.30	22.14	32.56
5	2.534	0.70	4.92	5.575	6.842	8.362	11.91	17.23	25.34
10	1.987	0.52	4.78	4.372	5.366	6.558	9.340	13.51	19.87
15	1.570	0.34	4.64	3.454	4.239	5.181	7.378	10.67	15.70
20	1.249	0.17	4.50	2.747	3.372	4.121	5.869	8.492	12.49
25	1.000	0.00	4.37	2.200	2.700	3.300	4.700	6.800	10.00
30	0.8059	0.16	4.25	1.773	2.176	2.660	3.788	5.480	8.059
35	0.6535	0.32	4.13	1.438	1.764	2.156	3.072	4.444	6.535
40	0.5330	0.47	4.02	1.173	1.439	1.759	2.505	3.624	5.330
45	0.4372	0.62	3.91	0.9618	1.180	1.443	2.055	2.972	4.372
50	0.3605	0.77	3.80	0.7932	0.973	1.190	1.694	2.451	3.606
55	0.2989	0.91	3.70	0.6575	0.807	0.9863	1.405	2.032	2.989
60	0.2490	1.05	3.60	0.5478	0.672	0.8217	1.170	1.693	2.490
65	0.2084	1.18	3.51	0.4586	0.562	0.6879	0.9797	1.417	2.084
70	0.1753	1.31	3.42	0.3857	0.473	0.5785	0.8239	1.192	1.753
75	0.1481	1.44	3.33	0.3258	0.399	0.4887	0.6960	1.007	1.481
80	0.1256	1.57	3.25	0.2764	0.339	0.4146	0.5905	0.8544	1.256
85	0.1070	1.69	3.16	0.2355	0.289	0.3532	0.5031	0.7278	1.070
90	0.09154	1.81	3.09	0.2014	0.247	0.3021	0.4303	0.6225	0.9154
95	0.07860	1.93	3.01	0.1729	0.212	0.2594	0.3694	0.5345	0.7860
100	0.06773	2.04	2.94	0.1490	0.182	0.2235	0.3183	0.4607	0.6773
105	0.05858	2.15	2.87	0.1289	0.158	0.1933	0.2753	0.3983	0.5858
110	0.05083	2.26	2.80	0.1118	0.137	0.1677	0.2389	0.3457	0.5083
115	0.04426	2.37	2.73	0.0974	0.1195	0.1461	0.2080	0.3010	0.4426
120	0.03866	2.47	2.67	0.0851	0.1044	0.1276	0.1817	0.2629	0.3866
125	0.03387	2.57	2.61	0.0745	0.0915	0.1118	0.1592	0.2303	0.3387
130	0.02977	2.67	2.55	0.0655	0.0804	0.0982	0.1399	0.2024	0.2977
135	0.02624	2.77	2.49	0.0577	0.0709	0.0866	0.1233	0.1784	0.2624
140	0.02319	2.86	2.43	0.0510	0.0626	0.0765	0.1090	0.1577	0.2319
145	0.02055	2.96	2.38	0.0452	0.0555	0.0678	0.0966	0.1398	0.2055
150	0.01826	3.05	2.33	0.0402	0.0493	0.0603	0.0858	0.1242	0.1826

Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 8, note 1		
				6.123	**6.153**	**6.223**
−40	25.78	6.81	6.09	309.4	386.8	567.2
−35	19.13	6.16	5.89	229.5	286.9	420.8
−30	14.32	5.53	5.70	171.8	214.8	315.0
−25	10.82	4.93	5.52	129.8	162.3	238.0
−20	8.245	4.35	5.35	98.93	123.7	181.4
−15	6.335	3.80	5.19	76.02	95.03	139.4
−10	4.907	3.26	5.03	58.88	73.60	107.9
−5	3.830	2.74	4.88	45.95	57.44	84.25
0	3.011	2.24	4.73	36.13	45.16	66.24
5	2.384	1.76	4.60	28.60	35.76	52.45
10	1.900	1.30	4.46	22.80	28.50	41.81
15	1.525	0.85	4.34	18.30	22.87	33.55
20	1.231	0.42	4.21	14.77	18.47	27.09
25	1.000	0.00	4.10	12.00	15.00	22.00
30	0.8170	0.41	3.98	9.804	12.26	17.97
35	0.6712	0.80	3.88	8.054	10.07	14.77
40	0.5543	1.19	3.77	6.652	8.315	12.20
45	0.4602	1.57	3.67	5.522	6.903	10.12
50	0.3839	1.94	3.57	4.607	5.759	8.447
55	0.3219	2.30	3.48	3.862	4.828	7.081
60	0.2710	2.65	3.39	3.252	4.067	5.963
65	0.2293	2.99	3.30	2.751	3.439	5.044
70	0.1947	3.33	3.22	2.337	2.921	4.284
75	0.1661	3.66	3.14	1.993	2.492	3.654
80	0.1422	3.98	3.06	1.707	2.134	3.129
85	0.1223	4.29	2.99	1.467	1.834	2.690
90	0.1055	4.60	2.92	1.266	1.583	2.321
95	0.09135	4.90	2.85	1.096	1.370	2.010
100	0.07937	5.19	2.78	0.9524	1.190	1.746
105	0.06919	5.48	2.71	0.8302	1.038	1.522
110	0.06050	5.76	2.65	0.7260	0.9075	1.331
115	0.05307	6.04	2.59	0.6369	0.7961	1.168
120	0.04670	6.31	2.53	0.5604	0.7005	1.027
125	0.04121	6.57	2.47	0.4945	0.6181	0.9065

Table 5 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 8, note 1	
				6.333	6.473
−40	33.81	5.55	6.55	1116	1589
−35	24.50	5.02	6.34	808.6	1151
−30	17.93	4.52	6.15	591.7	842.8
−25	13.25	4.03	5.96	437.1	622.6
−20	9.875	3.56	5.78	325.9	464.1
−15	7.425	3.10	5.61	245.0	349.0
−10	5.630	2.67	5.45	185.8	264.6
−5	4.304	2.24	5.29	142.0	202.3
0	3.315	1.84	5.14	109.4	155.8
5	2.573	1.44	4.99	84.91	120.9
10	2.011	1.07	4.85	66.37	94.53
15	1.583	0.70	4.72	52.24	74.40
20	1.254	0.34	4.59	41.39	58.95
25	1.000	0.00	4.46	33.00	47.00
30	0.8024	0.33	4.34	26.47	37.71
35	0.6474	0.66	4.23	21.37	30.43
40	0.5255	0.98	4.12	17.34	24.70
45	0.4288	1.28	4.01	14.15	20.15
50	0.3518	1.59	3.91	11.61	16.53
55	0.2901	1.88	3.81	9.572	13.63
60	0.2403	2.17	3.71	7.931	11.30
65	0.2001	2.45	3.62	6.603	9.404
70	0.1674	2.72	3.53	5.522	7.865
75	0.1406	2.99	3.44	4.639	6.607
80	0.1186	3.25	3.36	3.913	5.573
85	0.1004	3.51	3.28	3.315	4.721
90	0.08542	3.76	3.20	2.819	4.015
95	0.07292	4.00	3.13	2.406	3.427
100	0.06248	4.24	3.06	2.062	2.936
105	0.05372	4.47	2.98	1.773	2.525
110	0.04635	4.70	2.92	1.530	2.179
115	0.04013	4.93	2.85	1.342	1.886
120	0.03485	5.15	2.79	1.150	1.638
125	0.03037	5.36	2.73	1.002	1.427
130	0.02654	5.57	2.67	0.8757	1.247
135	0.02326	5.78	2.61	0.7675	1.093
140	0.02044	5.98	2.55	0.6746	0.9608
145	0.01802	6.18	2.50	0.5945	0.8468
150	0.01592	6.37	2.44	0.5254	0.7483

NTC thermistors, accuracy line 2322 640 6....

Table 6 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)	
				2322 640 .....; see Table 8, note 1	
				6.683	6.104
−40	36.66	5.69	6.70	2493	3666
−35	26.38	5.15	6.49	1794	2638
−30	19.17	4.63	6.29	1303	1917
−25	14.06	4.13	6.10	956.2	1406
−20	10.41	3.65	5.92	708.0	1041
−15	7.779	3.18	5.74	528.9	777.9
−10	5.861	2.73	5.57	398.5	586.1
−5	4.453	2.30	5.41	302.8	445.3
0	3.409	1.88	5.26	231.8	340.9
5	2.631	1.48	5.11	178.9	263.1
10	2.044	1.09	4.97	139.0	204.4
15	1.600	0.72	4.83	108.8	160.0
20	1.261	0.35	4.70	85.74	126.1
25	1.000	0.00	4.57	68.00	100.0
30	0.7981	0.34	4.45	54.27	79.81
35	0.6408	0.67	4.35	43.57	64.08
40	0.5175	1.00	4.22	35.19	51.74
45	0.4202	1.32	4.11	28.57	42.02
50	0.3431	1.63	4.00	23.33	34.31
55	0.2816	1.93	3.90	19.15	28.16
60	0.2322	2.22	3.80	15.79	23.22
65	0.1925	2.51	3.71	13.09	19.25
70	0.1602	2.79	3.62	10.90	16.03
75	0.1340	3.06	3.53	9.114	13.40
80	0.1126	3.33	3.45	7.655	11.26
85	0.09496	3.59	3.36	6.457	9.496
90	0.08042	3.85	3.28	5.469	8.042
95	.06837	4.10	3.21	4.649	6.837
100	0.05835	4.35	3.13	3.968	5.835
105	0.04998	4.59	3.06	3.399	4.998
110	0.04296	4.82	2.99	2.921	4.296
115	0.03705	5.05	2.92	2.519	3.705
120	0.03206	5.28	2.86	2.180	3.206
125	0.02783	5.50	2.80	1.892	2.783

NTC thermistors, accuracy line 2322 640 6....

Table 7 Resistance values at intermediate temperatures

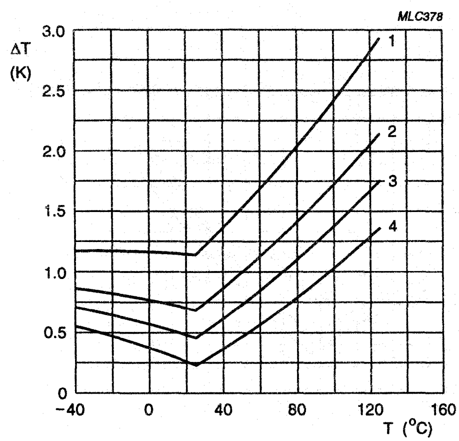
T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)	
				2322 640 .....; see Table 8, note 1	
				6.154	**6.224**
−40	41.02	10.10	6.89	6153	9024
−35	29.29	9.12	6.68	4394	6444
−30	21.12	8.18	6.48	3168	4646
−25	15.37	7.28	6.29	2305	3381
−20	11.28	6.42	6.11	1693	2483
−15	8.358	5.59	5.93	1254	1839
−10	6.242	4.80	5.76	936.4	1373
−5	4.700	4.03	5.60	705.0	1034
0	3.567	3.30	5.44	535.0	784.7
5	2.727	2.59	5.29	409.1	600.0
10	2.101	1.90	5.15	315.1	462.1
15	1.629	1.25	5.01	244.4	358.4
20	1.272	0.61	4.88	190.8	279.9
25	1.000	0.00	4.75	150.0	220.0
30	0.7910	0.59	4.62	118.6	174.0
35	0.6295	1.18	4.51	94.42	138.5
40	0.5039	1.74	4.39	75.58	110.9
45	0.4056	2.30	4.28	60.85	89.24
50	0.3283	2.84	4.17	49.25	72.24
55	0.2672	3.37	4.07	40.08	58.78
60	0.2185	3.89	3.97	32.78	48.08
65	0.1796	4.40	3.87	26.94	39.51
70	0.1483	4.90	3.78	22.25	32.63
75	0.1231	5.39	3.69	18.46	27.07
80	0.1025	5.86	3.60	15.38	22.56
85	0.08582	6.33	3.52	12.87	18.88
90	0.07213	6.79	3.44	10.82	15.87
95	0.06086	7.24	3.36	9.129	13.39
100	0.05155	7.68	3.28	7.732	11.34
105	0.04383	8.11	3.21	6.574	9.642
110	0.03740	8.53	3.14	5.610	8.228
115	0.03203	8.94	3.07	4.804	7.046
120	0.02752	9.35	3.00	4.128	6.054
125	0.02372	9.75	2.94	3.559	5.219

Table 8 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see note 1	
				6.334	6.474
−40	48.62	6.22	7.13	16044	22850
−35	34.19	5.63	6.91	11282	16068
−30	24.28	5.06	6.71	8013	11413
−25	17.42	4.51	6.52	5747	8185
−20	12.61	3.98	6.33	4161	5926
−15	9.211	3.47	6.15	3040	4329
−10	6.788	2.98	5.98	2240	3190
−5	5.045	2.51	5.82	1665	2371
0	3.781	2.06	5.66	1248	1776
5	2.855	1.62	5.50	942.3	1342
10	2.173	1.19	5.36	717.1	1021
15	1.666	0.78	5.22	549.8	783.0
20	1.286	0.38	5.08	424.5	604.6
25	1.000	0.00	4.95	330.0	470.0
30	0.7825	0.37	4.82	258.2	367.8
35	0.6163	0.74	4.70	203.4	289.6
40	0.4883	1.09	4.59	161.1	229.5
45	0.3892	1.44	4.47	128.4	182.9
50	0.3120	1.77	4.36	103.0	146.7
55	0.2515	2.10	4.26	83.00	118.2
60	0.2038	2.43	4.15	67.26	95.80
65	0.1660	2.74	4.06	54.79	78.03
70	0.1359	3.05	3.96	44.86	63.88
75	0.1118	3.35	3.87	36.90	52.55
80	0.09240	3.64	3.78	30.49	43.43
85	0.07670	3.93	3.69	25.31	36.05
90	0.06395	4.21	3.61	21.10	30.06
95	0.05354	4.48	3.53	17.67	25.16
100	0.04501	4.75	3.45	14.85	21.15
105	0.03798	5.01	3.37	12.53	17.85
110	0.03218	5.27	3.30	10.70	15.12
115	0.02736	5.52	3.23	9.029	12.86
120	0.02335	5.77	3.16	7.704	10.97
125	0.01999	6.01	3.09	6.597	9.396

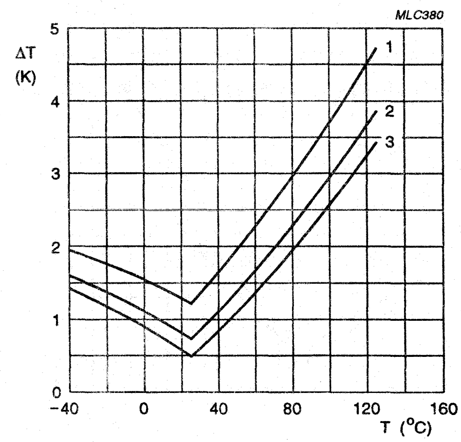
Note to Tables 3 through 8

1. Replace dot in last 5 digits of catalogue number by a number according to the following details and 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%.



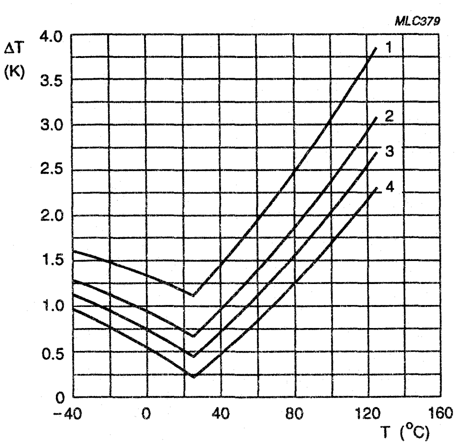
Curves valid for 2.2 to 10 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.
Curve 4: $\Delta R_{25}/R_{25}$ = 1% (for 2322 640 5.... series only).

Fig.3 Temperature deviation as a function of the ambient temperature.



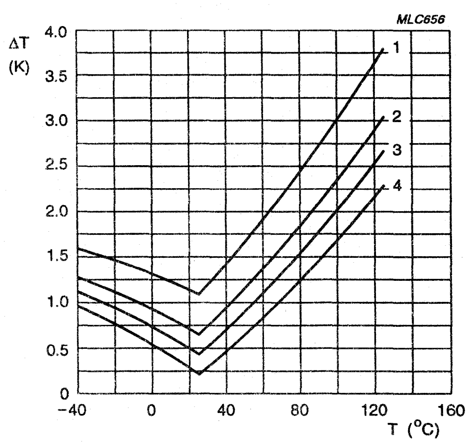
Curves valid for 12 to 22 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.

Fig.4 Temperature deviation as a function of the ambient temperature.



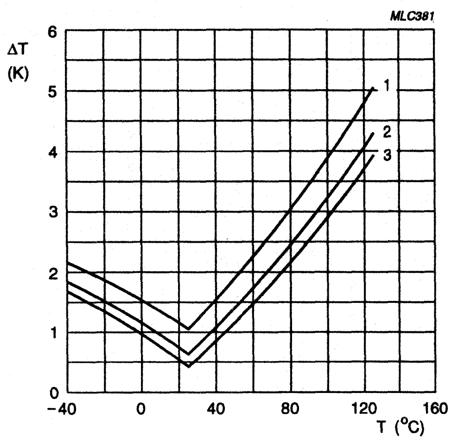
Curves valid for 33 to 47 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.
Curve 4: $\Delta R_{25}/R_{25}$ = 1% (for 2322 640 5.... series only).

Fig.5 Temperature deviation as a function of the ambient temperature.



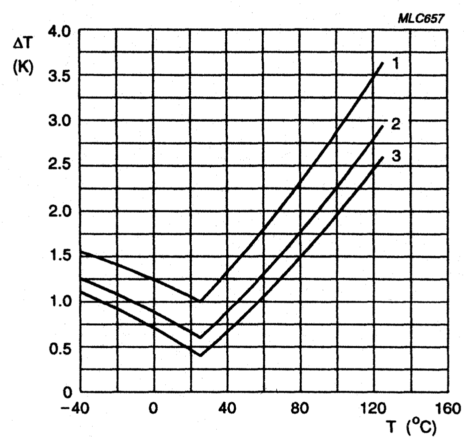
Curves valid for 68 to 100 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.
Curve 4: $\Delta R_{25}/R_{25}$ = 1% (for 2322 640 5.... series only).

Fig.6 Temperature deviation as a function of the ambient temperature.



Curves valid for 150 to 220 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.

Fig.7 Temperature deviation as a function of the ambient temperature.



Curves valid for 330 to 470 kΩ.
Curve 1: $\Delta R_{25}/R_{25}$ = 5%.
Curve 2: $\Delta R_{25}/R_{25}$ = 3%.
Curve 3: $\Delta R_{25}/R_{25}$ = 2%.

Fig.8 Temperature deviation as a function of the ambient temperature.

PACKAGING

The thermistors are packaged in cardboard boxes. Taped products are available on request.

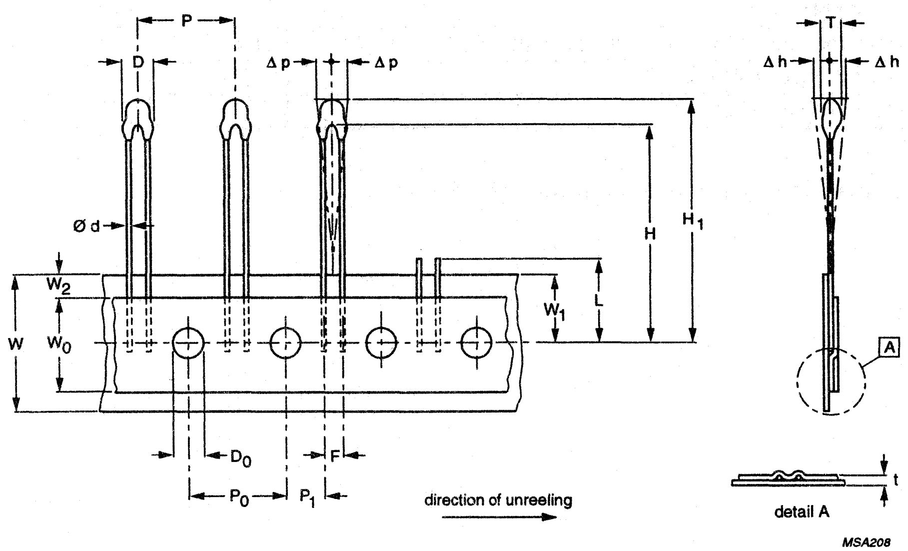
Table 9 Packaging information

PARAMETER	PACKAGING		
	BULK	TAPE AND REEL(1) 1E pitch	TAPE AND REEL(1) 2E pitch
Code number	2322 640 6....	2322 640 4....	2322 640 3....
Drawing	Fig.1	Fig.9	Fig.10
Quantity	500	1500 per reel, 2 reels per box	1500 per reel, 2 reels per box

Note

1. The maximum number of empty places per reel shall not exceed 0.5% of the total number of components per reel. No more than three consecutive positions may be vacant.

Tape and reel data



1E pitch
2322 640 4....
For dimensions see Table 10.

Fig.9 Thermistors on tape.

Table 10 Taping dimensions in accordance with *"IEC 286-2"*; see Fig.9

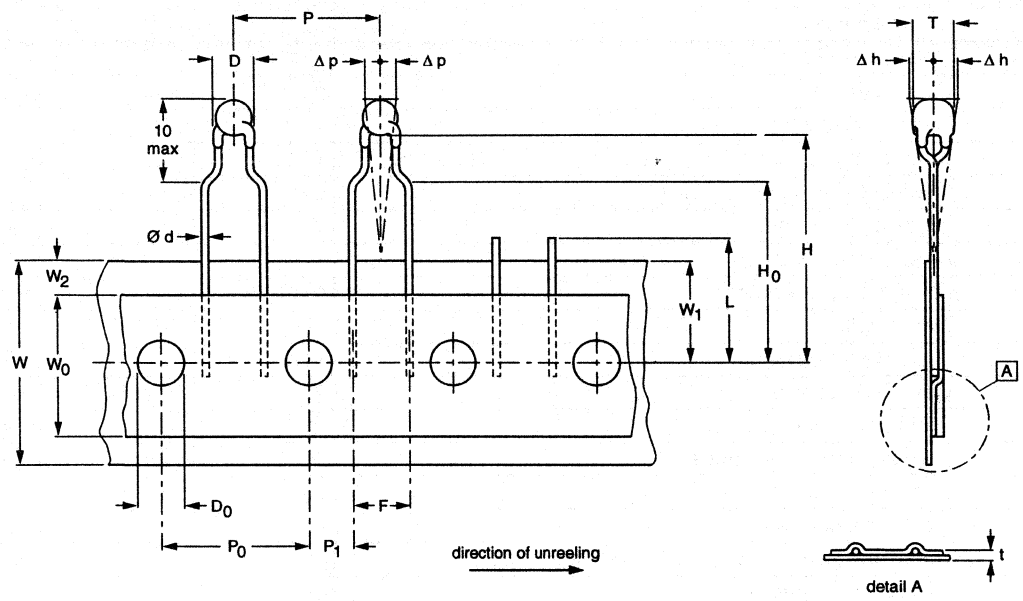
SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	body diameter	3.5	+0.3	mm
T	maximum total thickness	≤3	–	mm
d	lead diameter	0.6	±0.06	mm
P	pitch between thermistors	12.7	±1	mm
P_0	feed-hole pitch (cumulative pitch error ±0.2 mm/20 products)	12.7	±0.3	mm
P_1	feed-hole centre to lead centre	5.08	±0.7	mm
Δp	component alignment	0	±1.3	mm
F	lead-to-lead distance	2.54	±0.3	mm
Δh	component alignment	0	±2	mm
W	tape width	18	+1/–0.5	mm
W_0	hold-down tape width	≥12.5	–	mm
W_1	feed-hole position	9	±0.5	mm
W_2	hold-down tape position	≤3	–	mm
H	component to tape centre	22	–1	mm
H_1	component height	≤32.2(1)	–	mm
D_0	feed-hole diameter	4	±0.2	mm
t	total tape thickness with cardboard tape 0.5 ±0.1 mm	≤0.9	–	mm
L	length of snipped lead	≤11	–	mm
	AQL: mechanical level 11	–	1	%

Note

1. Taped products with H_1 = 48.5 +1.5/–0 mm available on request.

NTC thermistors, accuracy line

2322 640 6....

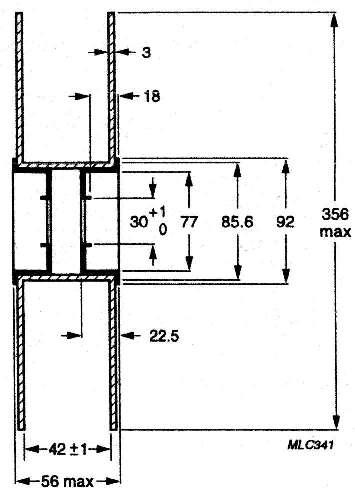


2E pitch
2322 640 3....
For dimensions see Table 11.

Fig.10 Thermistors on tape.

Table 11 Taping dimensions in accordance with *"IEC 286-2"*; see Fig.10

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	body diameter	3.5	+0.3	mm
T	total thickness	≤3.2	–	mm
d	lead diameter	0.6	0.06	mm
P	pitch between thermistors	12.7	±1	mm
P_0	feed-hole pitch (cumulative pitch error ±0.2 mm/20 products)	12.7	±0.3	mm
P_1	feed-hole centre to lead centre	3.85	±0.7	mm
Δp	component alignment	0	±1.3	mm
F	lead-to-lead distance	5	+0.6/–0.1	mm
Δh	component alignment	0	±2	mm
W	tape width	18	+1/–0.5	mm
W_0	hold-down tape width	≥12.5	–	mm
W_1	feed-hole position	9	+0.75/–0.5	mm
W_2	hold-down tape position	≤3	–	mm
H	component to tape centre	20	+1	mm
H_0	lead wire clinch height	16	±0.5	mm
D_0	feed-hole diameter	4	±0.3	mm
t	total tape thickness with cardboard tape 0.5 ±0.1 mm	0.7	±0.2	mm
L	length of snipped lead	≤11	–	mm
	AQL: mechanical level 11	–	1	%



Dimensions in mm.

Fig.11 Dimensions of the reel.

CHARACTERISTICS OF TAPED PRODUCTS

Minimum pull-out force of the component: 5 N.

Minimum peel-off force of adhesive tape: 6 N.

Minimum tearing force tape: 15 N.

Maximum peel-off force tape-reel: 5 N.

STORAGE CONDITIONS

Storage temperature range: –25 to +40 °C.

Maximum relative humidity: 80 °C.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with *"IEC publication 68-2; Environmental testing"*, except where indicated.

Table 12 Stability tests

IEC	CECC	TEST	PROCEDURE	TYPICAL DRIFT(1)	REQUIREMENTS
	D3; 4.20.1	endurance	25 °C; 1000 hours	ΔR/R = 0.1%	ΔR/R < 1%
68-2-1		endurance	−40 °C; 1000 hours	ΔR/R = 0.15%	ΔR/R < 1%
539		endurance	500 mW; 55 °C; 1000 hours	ΔR/R = 0.5%	ΔR/R < 3%; note 2
68-2-2		dry heat, steady state	125 °C; 1000 hours	ΔR/R ≤ 0.2%	ΔR/R < 3%
68-2-3	D1; 4.19	damp heat, steady state	56 days at 40 °C; 90 to 95% RH	ΔR/R = −0.2%	ΔR/R < 3%
68-2-14	C2; 4.14	rapid change of temperature	−40 °C to +125 °C; 50 cycles	ΔR/R = 0.1%	ΔR/R < 2%
Other applicable tests					
68-2-21		robustness of leads:			ΔR/R = ±1%
		tensile strength	loading force 10 N		
		bending	loading force 5 N		
		soldering:			ΔR/R = ±1%
		solderability	240 °C max.; duration 4 s max.		
		resistance to heat	265 °C max.; duration 11 s max.		
		impact	free fall; 1 m		ΔR/R = ±1%
		shock	490 m/s; half sinewave		
695-2-2		inflammability	1980, needle flame test		non-flammable

Notes

1. Typical drift is based on sample products with a $B_{25/85}$-value of 3977 K.
2. For R_{25} ≥ 100 kΩ the drift requirement is ΔR/R < 5%.

NTC thermistors, accuracy line (low values)

2322 640 6....

FEATURES

- Accuracy over a wide temperature range
- High stability over a long life
- Excellent price/performance ratio.

APPLICATION

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned solid copper-plated leads. It is grey lacquered and colour coded, but not insulated.

MECHANICAL DATA

Marking

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

Mounting

By soldering in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C	0.47 to 2	kΩ
Tolerance on R_{25}-value	±2; ±3; ±5	%
Tolerance on $B_{25/85}$-value	0.5 to 0.75	%
Maximum dissipation	500	mW
Response time	1.2	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 1	≤150	°C
at maximum dissipation (500 mW)	0 to 55	°C
Climatic category	40/125/56	
Mass	≈0.22	g

Note

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

Outline

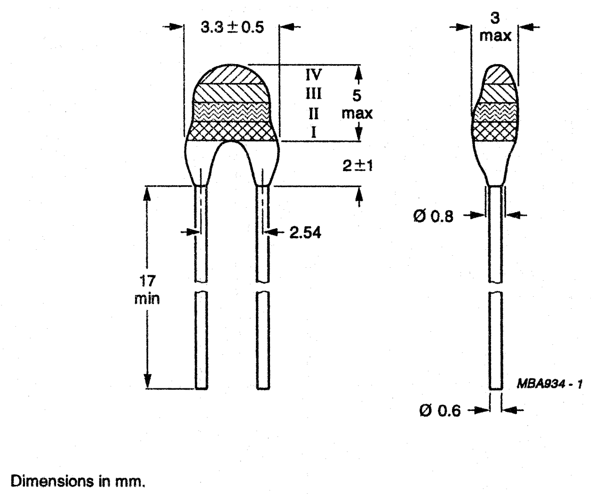


Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	VALUE	UNIT
Standard selection tolerance on R_{25}	±2; ±3; ±5	%
Climatic category	40/125/56	
Maximum dissipation	500	mW
Dissipation factor δ (for information only)	7	mW/K
Response time (for information only); note 1	1.2	s
Thermal time constant τ (for information only)	11	s
Operating temperature range:		
at zero dissipation; continuously	−40 to +125	°C
at zero dissipation; for short periods; note 2	≤150	°C
at maximum dissipation	0 to +55	°C

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 from 25 °C in air to 85 °C in oil.
2. For part of product range only, see Table 1.

Derating

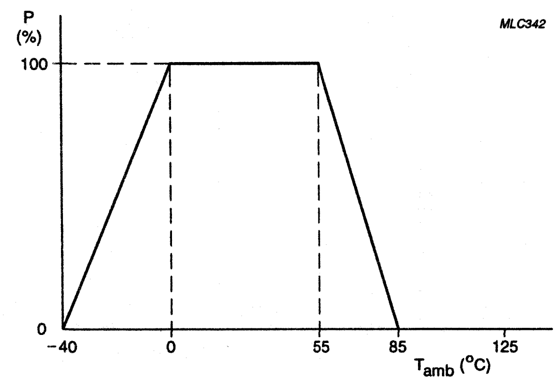


Fig.2 Power derating curve.

Table 1 R_{25}-values, catalogue numbers and coding; note 1

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 640 6....			COLOUR CODE (see Fig.1 and note 2)		
		R_{25} ±2%	R_{25} ±3%	R_{25} ±5%	I	II	III
0.47	3560 K ±0.75%	4471	6471	3471	yellow	violet	brown
1.0	3528 K ±0.5%	4102	6102	3102	brown	black	red
1.5	3528 K ±0.5%	4152	6152	3152	brown	green	red
2.0	3528 K ±0.5%	4202	6202	3202	red	black	red

Notes

1. Maximum operating temperature range at zero dissipation is 150 °C.
2. Dependent upon R_{25}-tolerance, the band IV is coloured as follows:
   a) for R_{25} ±2%; band IV is coloured red
   b) for R_{25} ±3%; band IV is coloured orange
   c) for R_{25} ±5%; band IV is coloured gold.

R_T value and tolerance

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 Tables 3 and 4, together with a formula to calculate the characteristics with a high precision.

Formulae to determine nominal resistance values(1)

The resistance values at intermediate temperatures, or the operating temperature values, can be calculated using the following interpolation laws (extended *"Steinhart and Hart"*):

$$R(T) = R_{ref} \times e^{A + B/T + C/T^2 + D/T^3} \quad (1)$$

$$T(R) = \left(A_1 + B_1 \ln\frac{R}{R_{ref}} + C_1 \ln^2\frac{R}{R_{ref}} + D_1 \ln^3\frac{R}{R_{ref}}\right)^{-1} \quad (2)$$

where:

A, B, C, D, A_1, B_1, C_1 and D_1 are constant values depending on the material concerned; see Table 2.

R_{ref} is the resistance value at a reference temperature (in this event 25 °C).

T is the temperature in K.

(1) Formulae numbered (1) and (2) are interchangeable with an error of max. 0.005 °C in the range 25 °C to 125 °C and max. 0.015 °C in the range –40 °C to 25 °C.

Determination of the resistance/temperature deviation from nominal value

The total resistance deviation is obtained by combining the 'R_{25}-tolerance' and the 'resistance deviation due to B-tolerance'.

When:

X = R_{25}-tolerance

Y = resistance deviation due to B-tolerance

Z = complete resistance deviation,

then: $$Z = \left[\left(1 + \frac{X}{100}\right) \times \left(1 + \frac{Y}{100}\right) - 1\right] \times 100\%$$

or $Z \approx X + Y$.

When:

TC = temperature coefficient

ΔT = temperature deviation,

then: $$\Delta T = \frac{Z}{TC}$$

Table 2 Parameters for determining nominal resistance values

$B_{25/85}$-VALUE (K)	A	$B \times 10^{-3}$ (K)	$C \times 10^{-5}$ (K^2)	$D \times 10^{-6}$ (K^3)	$A_1 \times 10^{-3}$ (K^{-1})	$B_1 \times 10^{-4}$ (K^{-1})	$C_1 \times 10^{-6}$ (K^{-1})	$D_1 \times 10^{-7}$ (K^{-1})
3528; note 1	–12.060	3.688	–0.076	–5.915	3.354016	2.909670	1.632136	0.719220
3528; note 2	–21.095	11.93	–25.139	248.12	3.354016	2.933908	3.494314	–7.71269
3560	–13.072	4.191	–0.472	–11.993	3.354016	2.884193	4.118032	1.786790

Notes

1. T < 298.15 K.
2. T > 298.15 K.

NTC thermistors, accuracy line (low values)

2322 640 6....

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)
				2322 640 .....; see Table 4, note 1
				6.471
–40	21.926	2.50	5.75	10503
–35	16.522	2.26	5.57	7766
–30	12.558	2.03	5.40	5902
–25	9.6249	1.81	5.24	4524
–20	7.4362	1.59	5.08	3495
–15	5.7898	1.39	4.93	2721
–10	4.5416	1.19	4.78	2135
–5	3.5881	1.00	4.64	1686
0	2.8550	0.82	4.51	1342
5	2.2860	0.64	4.38	1074
10	1.8425	0.48	4.25	865.9
15	1.4941	0.31	4.13	702.2
20	1.2189	0.15	4.01	572.9
25	1.0000	0.00	3.90	470.0
30	0.8250	0.15	3.80	387.7
35	0.6841	0.29	3.69	321.5
40	0.5703	0.43	3.59	268.0
45	0.4777	0.56	3.50	224.5
50	0.4020	0.69	3.40	188.9
55	0.3398	0.82	3.31	159.7
60	0.2886	0.94	3.23	135.6
65	0.2461	1.06	3.15	115.6
70	0.2107	1.18	3.07	99.00
75	0.1811	1.29	2.99	85.11
80	0.1562	1.40	2.91	73.43
85	0.1353	1.50	2.84	63.59
90	0.1176	1.60	2.77	55.26
95	0.1025	1.70	2.71	48.18
100	0.08968	1.80	2.64	42.15
105	0.07871	1.90	2.58	36.99
110	0.06928	1.99	2.52	32.56
115	0.06117	2.08	2.46	28.75
120	0.05416	2.16	2.41	25.46
125	0.04809	2.25	2.35	22.60
130	0.04282	2.33	2.30	20.12
135	0.03822	2.41	2.25	17.96
140	0.03420	2.49	2.20	16.07
145	0.03068	2.57	2.15	14.42
150	0.02758	2.65	2.10	12.96

Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)		
				2322 640 .....; note 1		
				6.102	6.152	6.202
−40	23.3402	1.65	6.06	23342	35013	46684
−35	17.3347	1.49	5.84	17336	26004	34672
−30	13.0166	1.34	5.62	13018	19526	26035
−25	9.8764	1.19	5.42	9877	14816	19754
−20	7.5682	1.05	5.23	7569	11353	15138
−15	5.8541	0.92	5.05	5855	8782	11709
−10	4.5688	0.79	4.87	4569	6854	9138
−5	3.5961	0.66	4.71	3596	5395	7193
0	2.8533	0.54	4.55	2854	4280	5707
5	2.2815	0.43	4.40	2282	3422	4563
10	1.8376	0.31	4.26	1838	2757	3675
15	1.4904	0.21	4.12	1491	2236	2981
20	1.2169	0.10	3.99	1217	1826	2434
25	1.000	0.00	3.87	1000	1500	2000
30	0.8266	0.10	3.75	826.7	1240	1653
35	0.6873	0.19	3.63	687.4	1031	1375
40	0.5746	0.28	3.53	574.6	861.9	1149
45	0.4827	0.37	3.42	482.7	724.1	965.0
50	0.4073	0.46	3.32	407.4	611.0	814.7
55	0.3452	0.54	3.23	345.2	517.8	690.5
60	0.2937	0.62	3.14	293.7	440.6	587.5
65	0.2508	0.70	3.05	250.8	376.2	501.7
70	0.2149	0.78	2.97	214.9	322.4	429.8
75	0.1847	0.85	2.89	184.8	277.1	369.5
80	0.1593	0.92	2.81	159.3	238.9	318.6
85	0.1377	0.99	2.73	137.7	206.6	275.5
90	0.11942	1.06	2.66	119.4	179.1	238.9
95	0.10380	1.13	2.59	103.8	155.7	207.6
100	0.09045	1.19	2.53	90.46	135.7	180.9
105	0.07900	1.25	2.46	79.00	118.5	158.0
110	0.06915	1.31	2.40	69.16	103.7	138.3
115	0.06066	1.37	2.34	60.66	90.99	121.3
120	0.05332	1.43	2.29	53.32	79.98	106.6
125	0.04696	1.49	2.23	46.96	70.44	93.9

NTC thermistors, accuracy line (low values)

2322 640 6....

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)		
				2322 640 .....; note 1		
				6.102	6.152	6.202
130	0.04143	1.54	2.18	41.44	62.15	82.9
135	0.03662	1.60	2.13	36.63	54.94	73.3
140	0.03243	1.65	2.08	32.43	48.65	64.9
145	0.02877	1.70	2.03	28.77	43.16	57.5
150	0.02556	1.75	1.98	25.56	38.34	51.1

Note

1. Replace dot in last 5 digits of catalogue number by a number according to the following details and 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%.

PACKAGING

The thermistors are packaged in cardboard boxes. Taped products are available on request.

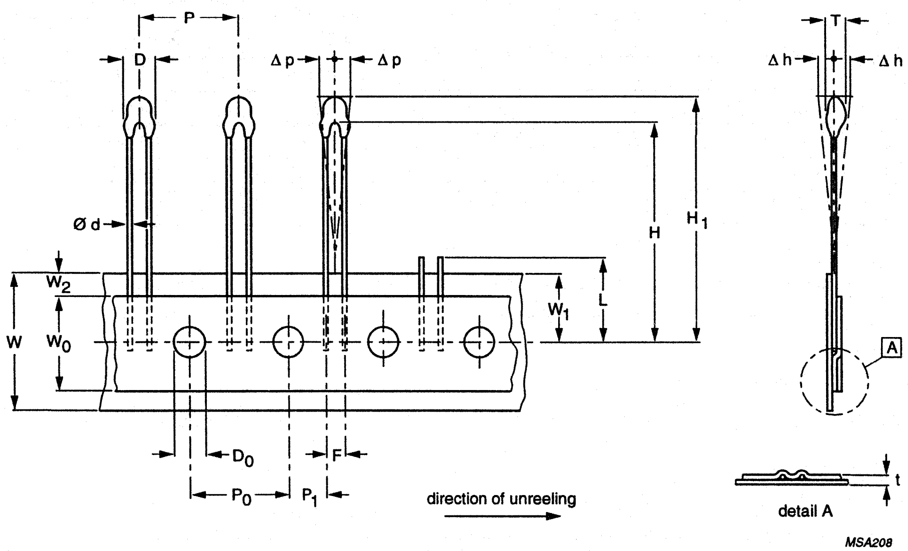
Table 5 Packaging information

PARAMETER	PACKAGING		
	BULK	TAPE AND REEL(1) 1E pitch	TAPE AND REEL(1) 2E pitch
Code number	2322 640 6....	2322 640 4....	2322 640 3....
Drawing	Fig.1	Fig.3	Fig.4
Quantity	500	1 500 per reel, 2 reels per box	1500 per reel, 2 reels per box

Note

1. The maximum number of empty places per reel shall not exceed 0.5% of the total number of components per reel. No more than three consecutive positions may be vacant.

Tape and reel data



1E pitch
2322 640 4....
For dimensions see Table 6.

Fig.3 Thermistors on tape.

NTC thermistors, accuracy line (low values)

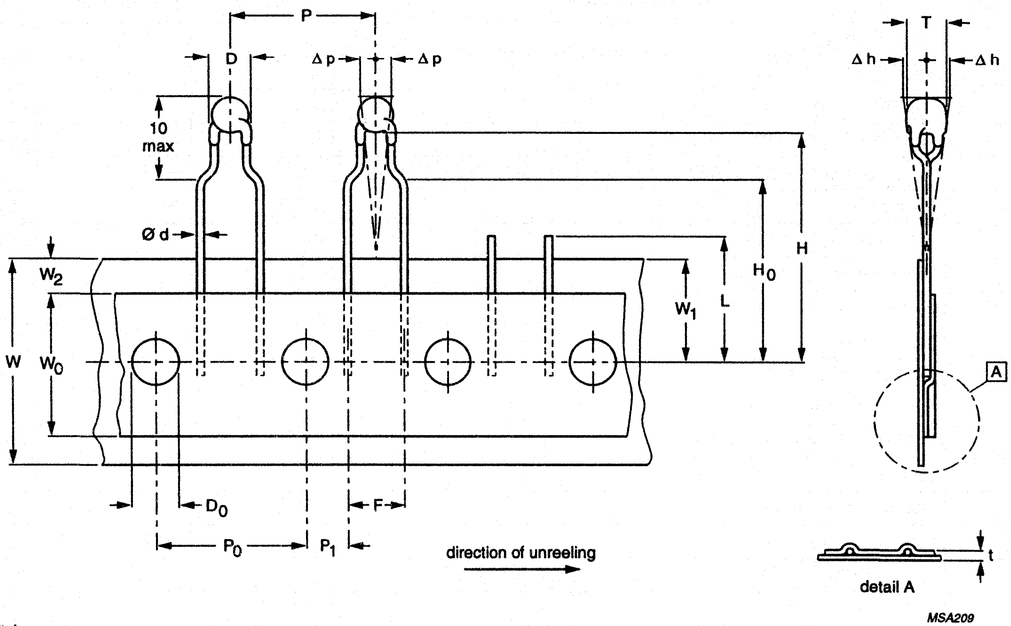
2322 640 6....

Table 6 Taping dimensions in accordance with *"IEC 286-2"*; see Fig.3

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	body diameter	3.5	+0.3	mm
T	maximum total thickness	≤3	–	mm
d	lead diameter	0.6	±0.06	mm
P	pitch between thermistors	12.7	±1	mm
P_0	feed-hole pitch (cumulative pitch error ±0.2 mm/20 products)	12.7	±0.3	mm
P_1	feed-hole centre to lead centre	5.08	±0.7	mm
Δp	component alignment	0	±1.3	mm
F	lead-to-lead distance	2.54	±0.3	mm
Δh	component alignment	0	±2	mm
W	tape width	18	+1/–0.5	mm
W_0	hold-down tape width	≥12.5	–	mm
W_1	feed-hole position	9	±0.5	mm
W_2	hold-down tape position	≤3	–	mm
H	component to tape centre	22	–1	mm
H_1	component height	≤32.2(1)	–	mm
D_0	feed-hole diameter	4	±0.2	mm
t	total tape thickness with cardboard tape 0.5 ±0.1 mm	≤0.9	–	mm
L	length of snipped lead	≤11	–	mm
	AQL: mechanical level 11	–	1	%

Note

1. Taped products with H_1 = 48.5 +1.5/–0 mm available on request.

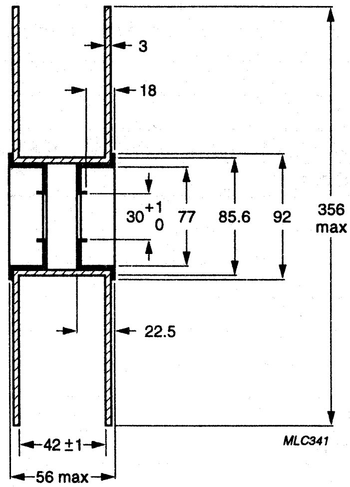


2E pitch
2322 640 3....
For dimensions see Table 7.

Fig.4 Thermistors on tape.

Table 7 Taping dimensions in accordance with *"IEC 286-2"*; see Fig.4

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
D	body diameter	3.5	+0.3	mm
T	total thickness	≤3.2	–	mm
d	lead diameter	0.6	0.06	mm
P	pitch between thermistors	12.7	±1	mm
P_0	feed-hole pitch (cumulative pitch error ±0.2 mm/20 products)	12.7	±0.3	mm
P_1	feed-hole centre to lead centre	3.85	±0.7	mm
Δp	component alignment	0	±1.3	mm
F	lead-to-lead distance	5	+0.6/–0.1	mm
Δh	component alignment	0	±2	mm
W	tape width	18	+1/–0.5	mm
W_0	hold-down tape width	≥12.5	–	mm
W_1	feed-hole position	9	+0.75/–0.5	mm
W_2	hold-down tape position	≤3	–	mm
H	component to tape centre	20	+1	mm
H_0	lead wire clinch height	16	±0.5	mm
D_0	feed-hole diameter	4	±0.3	mm
t	total tape thickness with cardboard tape 0.5 ±0.1 mm	0.7	±0.2	mm
L	length of snipped lead	≤11	–	mm
	AQL: mechanical level 11	–	1	%



Dimensions in mm.

Fig.5 Dimensions of the reel.

CHARACTERISTICS OF TAPED PRODUCTS

Minimum pull-out force of the component: 5 N.

Minimum peel-off force of adhesive tape: 6 N.

Minimum tearing force tape: 15 N.

Maximum peel-off force tape-reel: 5 N.

STORAGE CONDITIONS

Storage temperature range: –25 to +40 °C.

Maximum relative humidity: 80 °C.

NTC thermistors, accuracy line — 2322 645 series

FEATURES

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

APPLICATIONS

- Temperature sensing and control up to 150 °C
- Temperature compensation.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned solid copper leads. 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 and the choice of R_{25}-values is 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.

PACKAGING

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

MECHANICAL DATA

Marking

Grey lacquered.

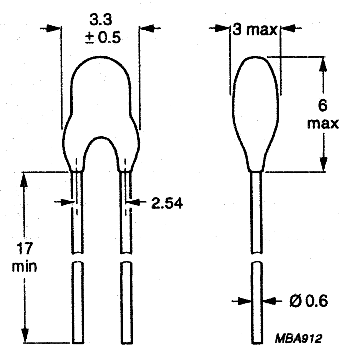
Mounting

By soldering in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	5 to 10	kΩ
$B_{25/75}$-value	3965	K
Tolerance on $B_{25/75}$-value	±0.75	%
Maximum dissipation	100	mW
Response time (for information only)	1.2	s
Operating temperature range:		
at zero dissipation	−40 to +125	°C
for short periods	≤150	°C
at maximum dissipation	0 to +55	°C
Climatic category	40/125/56	
Mass	≈0.22	g

Outline



Dimensions in mm.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*; see also Table 1. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*;

PARAMETER	VALUE	UNIT
Standard selection tolerance on R_{25}	±5	%
Climatic category	40/125/56	
Maximum dissipation	100	mW
Dissipation factor δ (for information only)	7	mW/K
Response time (for information only); note 1	1.2	s
Thermal time constant τ (for information only)	11	s
Operating temperature range (see Fig.2):		
at zero dissipation (continuously)	−40 to +125	°C
for short periods	≤150	°C
at maximum dissipation	0 to +150	°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 from 25 °C in air to 85 °C in oil.

Table 1 R_{25}-values and catalogue numbers

R_{25}-VALUE (kΩ)	CATALOGUE NUMBER 2322 645 .....
	TOLERANCE ±5%
5	03502
6	03602
8	03802
10	03103

Derating

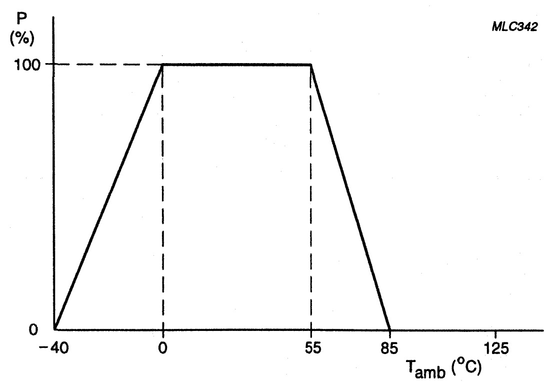


Fig.2 Power derating curve.

R_T value and tolerance

These thermistors have a narrow tolerance on the B-value, 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 3, together with a formula to calculate the characteristics with a high precision.

Formula to determine nominal resistance values

The resistance values at intermediate temperatures, or at the operating temperature values, can be calculated using the following interpolation laws (extended *"Steinhart and Hart"*):

$$R(T) = R_{ref} \times e^{A + B/T + C/T^2 + D/T^3}$$

$$T(R) = \left(A_1 + B_1 \ln\frac{R}{R_{ref}} + C_1 \ln^2\frac{R}{R_{ref}} + D_1 \ln^3\frac{R}{R_{ref}}\right)^{-1}$$

where:

A, B, C, D, A_1, B_1, C_1 and D_1 are constant values depending on the material concerned; see Table 2.

R_{ref} is the resistance value at a reference temperature (in this event 25 °C)

T is the temperature in K.

Determination of the resistance/temperature deviation from nominal value

The total resistance deviation is obtained by combining the 'R_{25}-tolerance' and the 'resistance deviation due to B-tolerance'.

When:

X = R_{25}-tolerance

Y = resistance deviation due to B-tolerance

Z = complete resistance deviation,

then:

$$Z = \left[\left(1 + \frac{X}{100}\right) \times \left(1 + \frac{Y}{100}\right) - 1\right] \times 100\%$$

or $Z \approx X + Y$.

When:

TC = temperature coefficient

ΔT = temperature deviation,

then:

$$\Delta T = \frac{Z}{TC}$$

EXAMPLE

At 0 °C, assume X = 5%, Y = 0.89% and TC = 5.08%/K (see Table 3), then:

$$Z = \left\{\left[1 + \frac{5}{100}\right] \times \left[1 + \frac{0.89}{100}\right] - 1\right\} \times 100\%$$

$$= \{1.05 \times 1.0089 - 1\} \times 100\% = 5.9345\% \; (\approx 5.93\%)$$

$$\Delta T = \frac{Z}{TC} = \frac{5.93}{5.08} = 1.167\ °C \; (\approx 1.17\ °C)$$

A NTC with a R_{25}-value of 10 kΩ has a value of 32.51 kΩ between −1.17 and +1.17 °C.

Table 2 Parameters for determining nominal resistance values

B (K)	A	B (K)	C (K^2)	D (K^3)	$A_1 \times 10^{-3}$	$B_1 \times 10^{-4}$ (K)	$C_1 \times 10^{-6}$ (K^2)	$D_1 \times 10^{-7}$ (K^3)
3977	−14.6337	4791.842	−115334	−3730535	3.353832	2.569355	2.626311	0.675278

Table 3 Resistance values at intermediate temperatures

T_{oper} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 645 .....(1)			
				0.502	0.602	0.802	0.103
–40	33.21	2.66	6.57	166.1	199.3	265.7	332.1
–35	23.99	2.41	6.36	120.0	143.9	191.9	239.9
–30	17.52	2.17	6.15	87.60	105.1	140.2	175.2
–25	12.93	1.94	5.95	64.65	77.57	103.4	129.3
–20	9.636	1.71	5.76	48.18	57.82	77.09	96.36
–15	7.250	1.50	5.58	36.25	43.50	58.00	72.50
–10	5.505	1.29	5.40	27.52	33.03	44.04	55.05
–5	4.216	1.08	5.24	21.08	25.30	33.73	42.16
0	3.255	0.89	5.08	16.28	19.53	26.04	32.56
5	2.534	0.70	4.92	12.67	15.20	20.27	25.34
10	1.987	0.52	4.78	9.936	11.92	15.90	19.87
15	1.570	0.34	4.64	7.849	9.419	12.56	15.70
20	1.249	0.17	4.50	6.244	7.493	9.990	12.49
25	1.000	0.00	4.37	5.000	6.000	8.000	10.00
30	0.8059	0.16	4.25	4.030	4.836	6.447	8.059
35	0.6535	0.32	4.13	3.267	3.921	5.228	6.535
40	0.5330	0.47	4.02	2.665	3.198	4.264	5.330
45	0.4372	0.62	3.91	2.186	2.623	3.497	4.372
50	0.3605	0.77	3.80	1.803	2.163	2.884	3.606
55	0.2989	0.91	3.70	1.494	1.793	2.391	2.989
60	0.2490	1.05	3.60	1.245	1.494	1.992	2.490
65	0.2084	1.18	3.51	1.042	1.251	1.668	2.084
70	0.1753	1.31	3.42	0.8765	1.052	1.402	1.753
75	0.1481	1.44	3.33	0.7405	0.8886	1.185	1.481
80	0.1256	1.57	3.25	0.6282	0.7538	1.005	1.256
85	0.1070	1.69	3.16	0.5352	0.6422	0.8563	1.070
90	0.09154	1.81	3.09	0.4577	0.5493	0.7324	0.9154
95	0.07860	1.93	3.01	0.3930	0.4716	0.6288	0.7860
100	0.06773	2.04	2.94	0.3387	0.4064	0.5419	0.6773
105	0.05858	2.15	2.87	0.2929	0.3515	0.4686	0.5858
110	0.05083	2.26	2.80	0.2542	0.3050	0.4067	0.5083
115	0.04426	2.37	2.73	0.2213	0.2656	0.3541	0.4426
120	0.03866	2.47	2.67	0.1933	0.2320	0.3093	0.3866
125	0.03387	2.57	2.61	0.1694	0.2032	0.2710	0.3387
130	0.02977	2.67	2.55	0.1488	0.1786	0.2382	0.2977
135	0.02624	2.77	2.49	0.1312	0.1574	0.2099	0.2624
140	0.02319	2.86	2.43	0.1160	0.1391	0.1855	0.2319
145	0.02055	2.96	2.38	0.1028	0.1233	0.1644	0.2055
150	0.01826	3.05	2.33	0.0913	0.1096	0.1461	0.1826

Note

1. Replace dot in last 5 digits of catalogue number by 3 for ±5% tolerance on required R_{25}-value.

NTC thermistors, special accuracy

2322 640 10...

FEATURES

- Excellent accuracy between 25 °C and 85 °C
- High stability over a long life.

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned copper-plated leads. It is grey lacquered and not insulated. These thermistors are very accurate over a trajectory from 25 °C to 85 °C.

PACKAGING

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

MECHANICAL DATA

Marking

Grey lacquered body.

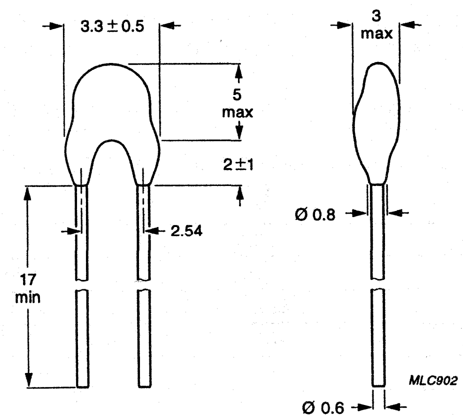
Mounting

By soldering in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	4.7 to 100	kΩ
Tolerance on R_{25}-value	±0.5	°C
Resistance value at 85 °C	0.5029 to 9.498	kΩ
Tolerance on R_{85}-value	±0.5	°C
Maximum dissipation	250	mW
Response time (for information only)	1.2	s
Operating temperature range:		
at zero dissipation	−40 to +125	°C
at maximum dissipation	0 to +55	°C
Climatic category	40/125/56	
Mass	≈0.22	g

Outline



Dimensions in mm.

Fig.1 Component outline.

NTC thermistors, special accuracy 2322 640 10...

ELECTRICAL CHARACTERISTICS

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

PARAMETER	VALUE	UNIT
Resistance at 25 °C; note 1	4.7 to 100	kΩ
Tolerance on R_{25}-value	±0.5	°C
Resistance at 85 °C	0.5029 to 9.498	kΩ
Tolerance on R_{85}-value	±0.5	°C
Climatic category	40/125/56	
Maximum dissipation	250	mW
Dissipation factor δ (for information only)	7	mW/K
Response time (for information only); note 2	1.2	s
Thermal time constant τ (for information only)	11	s
Operating temperature range:		
at zero dissipation (continuously)	−40 to +125	°C
at maximum dissipation	0 to +55	°C

Notes

1. For values of nominal resistance value and tolerance at intermediate temperatures; see Tables 2, 3 and 4.
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 from 25 °C in air to 85 °C in oil.

Table 1 R_{25} and R_{85}-values, TC-value and catalogue numbers

R_{25}-VALUE ±0.5 °C (kΩ)	R_{85}-VALUE ±0.5 °C (Ω)	$B_{25/85}$-VALUE (TYPICAL)	TC AT 25 °C (%/K)	CATALOGUE NUMBER 2322 640 .....
4.7	502.9	3977	−4.37	10472
10	1070	3977	−4.37	10103
47	4721	4090	−4.46	10473
100	9498	4190	−4.57	10104

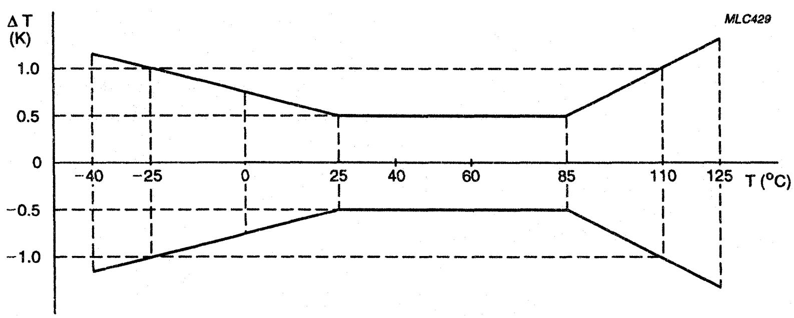


Fig.2 Tolerance curve.

NTC thermistors, special accuracy 2322 640 10...

Table 2 Resistance values at intermediate values

T_{oper} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640	
				10472	10103
−40	33.21	2.66	6.57	156.1	332.1
−35	23.99	2.41	6.36	112.8	240.0
−30	17.52	2.17	6.15	82.35	175.2
−25	12.93	1.94	5.95	60.77	129.3
−20	9.636	1.71	5.76	45.30	96.36
−15	7.250	1.50	5.58	34.08	72.50
−10	5.505	1.29	5.40	25.87	55.05
−5	4.216	1.08	5.24	19.81	42.16
0	3.255	0.89	5.08	15.30	32.56
5	2.534	0.70	4.92	11.91	25.34
10	1.987	0.52	4.78	9.340	19.87
15	1.570	0.34	4.64	7.378	15.70
20	1.249	0.17	4.50	5.869	12.49
25	1.000	0.00	4.37	4.700	10.00
30	0.8059	0.16	4.25	3.788	8.059
35	0.6535	0.32	4.13	3.072	6.535
40	0.5330	0.47	4.02	2.505	5.330
45	0.4372	0.62	3.91	2.055	4.372
50	0.3605	0.77	3.80	1.694	3.606
55	0.2989	0.91	3.70	1.405	2.989
60	0.2490	1.05	3.60	1.170	2.490
65	0.2084	1.18	3.51	0.9797	2.084
70	0.1753	1.31	3.42	0.8239	1.753
75	0.1481	1.44	3.33	0.6960	1.481
80	0.1256	1.57	3.25	0.5905	1.256
85	0.1070	1.69	3.16	0.5031	1.070
90	0.09154	1.81	3.09	0.4303	0.9154
95	0.07860	1.93	3.01	0.3694	0.7860
100	0.06773	2.04	2.94	0.3183	0.6773
105	0.05858	2.15	2.87	0.2753	0.5858
110	0.05083	2.26	2.80	0.2389	0.5083
115	0.04426	2.37	2.73	0.2080	0.4426
120	0.03866	2.47	2.67	0.1817	0.3866
125	0.03387	2.57	2.61	0.1592	0.3387
130	0.02977	2.67	2.55	0.1399	0.2977
135	0.02624	2.77	2.49	0.1233	0.2624
140	0.02319	2.86	2.43	0.1090	0.2319
145	0.02055	2.96	2.38	0.0966	0.2055
150	0.01826	3.05	2.33	0.0858	0.1826

Table 3 Resistance values at intermediate values

T_{oper} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)
				2322 640 10473
−40	33.81	5.55	6.55	1589
−35	24.50	5.02	6.34	1151
−30	17.93	4.52	6.15	842.8
−25	13.25	4.03	5.96	622.6
−20	9.875	3.56	5.78	464.1
−15	7.425	3.10	5.61	349.0
−10	5.630	2.67	5.45	264.6
−5	4.304	2.24	5.29	202.3
0	3.315	1.84	5.14	155.8
5	2.573	1.44	4.99	120.9
10	2.011	1.07	4.85	94.53
15	1.583	0.70	4.72	74.40
20	1.254	0.34	4.59	58.95
25	1.000	0.00	4.46	47.00
30	0.8024	0.33	4.34	37.71
35	0.6474	0.66	4.23	30.43
40	0.5255	0.98	4.12	24.70
45	0.4288	1.28	4.01	20.15
50	0.3518	1.59	3.91	16.53
55	0.2901	1.88	3.81	13.63
60	0.2403	2.17	3.71	11.30
65	0.2001	2.45	3.62	9.404
70	0.1674	2.72	3.53	7.865
75	0.1406	2.99	3.44	6.607
80	0.1186	3.25	3.36	5.573
85	0.1004	3.51	3.28	4.721
90	0.08542	3.76	3.20	4.015
95	0.07292	4.00	3.13	3.427
100	0.06248	4.24	3.06	2.936
105	0.05372	4.47	2.98	2.525
110	0.04635	4.70	2.92	2.179
115	0.04013	4.93	2.85	1.886
120	0.03485	5.15	2.79	1.638
125	0.03037	5.36	2.73	1.427
130	0.02654	5.57	2.67	1.247
135	0.02326	5.78	2.61	1.093
140	0.02044	5.98	2.55	0.9608
145	0.01802	6.18	2.50	0.8468
150	0.01592	6.37	2.44	0.7483

Table 4 Resistance values at intermediate values

T_{oper} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 10104
−40	36.66	5.69	6.70	3666
−35	26.38	5.15	6.49	2638
−30	19.17	4.63	6.29	1917
−25	14.06	4.13	6.10	1406
−20	10.41	3.65	5.92	1041
−15	7.779	3.18	5.74	777.9
−10	5.861	2.73	5.57	586.1
−5	4.453	2.30	5.41	445.3
0	3.409	1.88	5.26	340.9
5	2.631	1.48	5.11	263.1
10	2.044	1.09	4.97	204.4
15	1.600	0.72	4.83	160.0
20	1.261	0.35	4.70	126.1
25	1.000	0.00	4.57	100.0
30	0.7981	0.34	4.45	79.81
35	0.6408	0.67	4.35	64.08
40	0.5175	1.00	4.22	51.74
45	0.4202	1.32	4.11	42.02
50	0.3431	1.63	4.00	34.31
55	0.2816	1.93	3.90	28.16
60	0.2322	2.22	3.80	23.22
65	0.1925	2.51	3.71	19.25
70	0.1602	2.79	3.62	16.03
75	0.1340	3.06	3.53	13.40
80	0.1126	3.33	3.45	11.26
85	0.09496	3.59	3.36	9.496
90	0.08042	3.85	3.28	8.042
95	0.06837	4.10	3.21	6.837
100	0.05835	4.35	3.13	5.835
105	0.04998	4.59	3.06	4.998
110	0.04296	4.82	2.99	4.296
115	0.03705	5.05	2.92	3.705
120	0.03206	5.28	2.86	3.206
125	0.02783	5.50	2.80	2.783

NTC THERMISTOR
low temperature

Features

- Excellent accuracy over a wide temperature range
- High stability over a long life

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

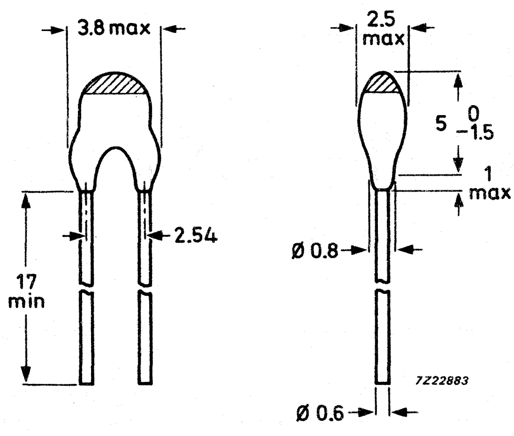


Fig.1 Component outline.

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

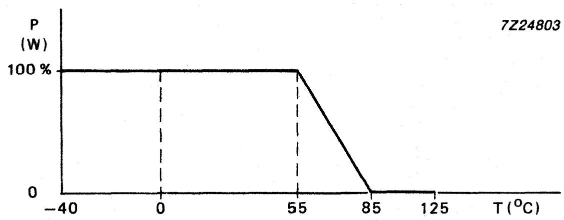


Fig.2 Tolerance curve.

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

NTC thermistors, special accuracy | 2322 640 90106

FEATURES

- Excellent accuracy over a wide temperature range
- High stability over a long life
- Especially designed for the thermal switch circuit in a refrigerator thermostat.

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned nickel leads. 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.

PACKAGING

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

MECHANICAL DATA

Marking

Black lacquered body.

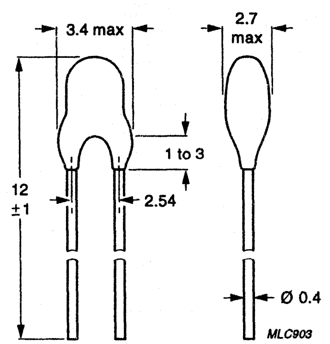
Mounting

By soldering in any position. The leads are suitable for printed-circuit board applications.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value:		
at 25 °C	9985 ±2.3%	Ω
at 0 °C	32510 ±1.4%	Ω
$B_{25/85}$-value	3977 ±0.75%	K
Maximum dissipation	100	mW
Response time (for information only)	1.7	s
Thermal time constant τ (for information only)	13	s
Operating temperature range:		
at zero dissipation	−55 to +125	°C
for short periods	≤150	°C
at maximum dissipation	−55 to +55	°C
Dissipation factor (for information only)	2.2	mW/K
Climatic category	40/125/56	
Mass	≈0.11	g

Outline



Dimensions in mm.
The non-dimensioned details do not affect the performance of the device.

Fig.1 Component outline.

NTC thermistors, special accuracy | 2322 640 90106

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"* and *"CECC 43000"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Climatic category	40/125/56	
Maximum dissipation	100	mW
Resistance: at 25 °C at 0 °C	 9985 ±2.3% 32510 ±1.4%	 Ω Ω
$B_{25/85}$-value	3977 ±0.75%	K
Response time (for information only); note 1	1.7	s
Operating temperature range	0 to +55	°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 from 25 °C in air to 85 °C in oil.

Derating

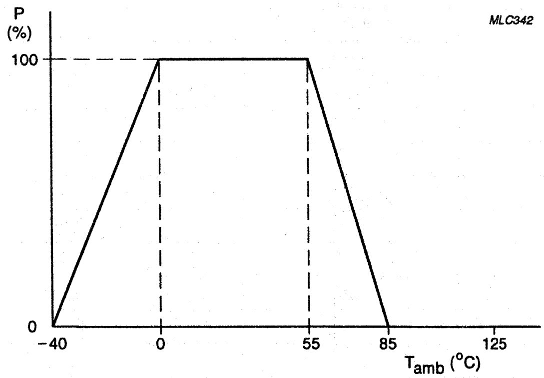


Fig.2 Power derating curve.

NTC thermistors, special accuracy 2322 640 90106

Table 1 Resistance values at intermediate temperatures

T_{amb} (°C)	RESISTANCE (Ω)	TC (%/K)	ΔR DUE TO B-TOLERANCE (%)
–40	331989	6.62	3.18
–35	239768	6.39	2.93
–30	175069	6.18	2.69
–25	129170	5.97	2.45
–20	96258.3	5.78	2.23
–15	72417.4	5.60	2.01
–10	54978.1	5.41	1.80
–5	42102	5.25	1.59
0	32510	5.09	1.40
5	25303	5.93	1.59
10	19843.6	4.79	1.78
15	15675.5	4.64	1.96
20	12469.2	4.51	2.13
25	9985.0	4.38	2.30
30	8046.9	4.25	2.47
35	6524.8	4.13	2.63
40	5321.8	4.02	2.79
45	4365.1	3.91	2.94
50	3599.8	3.80	3.09
55	2984.1	3.70	3.23
60	2486.2	3.60	3.37
65	2081.2	3.51	3.51
70	1750.4	3.42	3.65
75	1478.6	3.33	3.78
80	1254.5	3.25	3.91
85	1068.7	3.16	4.03
90	914.0	3.09	4.15
95	784.7	3.01	4.27
100	676.2	2.94	4.39
105	584.8	2.87	4.50
110	507.5	2.80	4.61
115	441.9	2.74	4.72
120	386.0	2.67	4.83
125	338.2	2.61	4.93
130	297.2	2.55	5.03
135	262.0	2.50	5.13
140	231.6	2.44	5.23
145	205.2	2.39	5.33
150	182.3	2.34	5.42

NTC thermistors, special accuracy — 2322 640 90109

FEATURES

- Excellent accuracy over a wide temperature range
- High stability over a long life
- Especially designed for temperature regulation in washing machines.

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned nickel leads. 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.

PACKAGING

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

MECHANICAL DATA

Marking

Beige lacquered body.

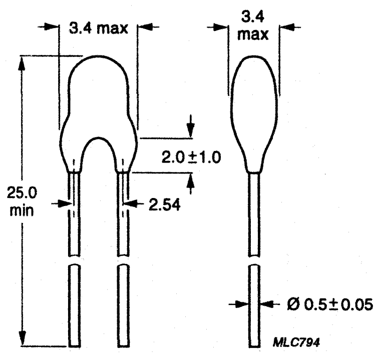
Mounting

By soldering in any position. The leads are suitable for printed-circuit board applications.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value:		
at 25 °C	4700 +8/−4%	Ω
at 100 °C	330 ±3%	Ω
at 150 °C	90 ±6%	Ω
$B_{25/85}$-value (for information only)	3977	K
Maximum dissipation	0.25	W
Operating temperature range	−40 to +150	°C
Climatic category	40/150/56	
Mass	≈0.11	g

Outline



Dimensions in mm.
The non-dimensioned details do not affect the performance of the device.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"* and *"CECC 43000"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Climatic category	40/150/56	
Maximum dissipation	0.25	W
Resistance:		
at 25 °C	4700 +8/–4%	Ω
at 100 °C	330 ±3%	Ω
at 150 °C	90 ±6%	Ω
$B_{25/85}$-value (for information only)	3977	K
Temperature coefficient (for information only)	4.38	%/K
Operating temperature range	–40 to +150	°C

Derating

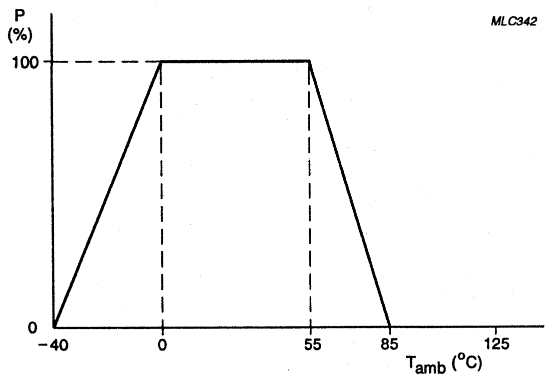


Fig.2 Power derating curve.

NTC thermistors, special accuracy | 2322 640 90109

Table 1 Resistance values at intermediate temperatures

T_{amb} (°C)	RESISTANCE (Ω)	TC (%/K)	RESISTANCE TOLERANCE (%)
−40	157761	6.62	−5
−35	113898	6.40	
−30	83139	6.18	
−25	61326	5.98	
−20	45690	5.78	
−15	34367	5.60	
−10	26087	5.42	
−5	19974	5.25	
0	15422	5.09	
5	12002	4.93	
10	9412	4.79	
15	7434	4.64	
20	5913	4.51	
25	4700	4.38	−2
30	3824	4.25	
35	3107	4.13	
40	2540	4.02	
45	2087	3.91	
50	1725	3.80	
55	1432	3.70	
60	1196	3.60	
65	1003	3.51	
70	845	3.42	
75	715	3.33	
80	607	3.25	
85	518	3.16	
90	444	3.09	
95	382	3.01	
100	330	2.94	−3
105	285	2.87	
110	248	2.80	
115	216	2.74	
120	189	2.67	
125	166	2.61	
130	146	2.55	
135	129	2.50	
140	114	2.44	
145	101	2.39	
150	90	2.34	−6

NTC thermistors, special accuracy 2322 640 90112

FEATURES

- Excellent accuracy over a wide temperature range
- High stability over a long life
- Especially designed for temperature regulation in washing machines.

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two tinned nickel leads. 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.

PACKAGING

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

MECHANICAL DATA

Marking

Beige lacquered body.

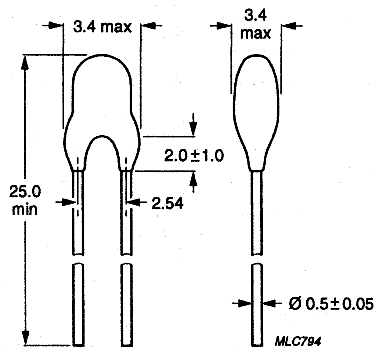
Mounting

By soldering in any position. The leads are suitable for printed-circuit board applications.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value:		
at 25 °C	12	kΩ
at 30 °C	9787 ±4.6%	Ω
at 80 °C	1704 ±2%	Ω
at 95 °C	1093 ±2.7%	Ω
at 100 °C	950 ±2.9%	Ω
$B_{25/100}$-value	3760 ±1.5%	K
Maximum dissipation	250	mW
Operating temperature range	−40 to +125	°C
Climatic category	40/125/56	
Mass	≈0.11	g

Outline



Dimensions in mm.
The non-dimensioned details do not affect the performance of the device.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"* and *"CECC 43000"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Climatic category	40/125/56	
Maximum dissipation	250	mW
Resistance value:		
at 30 °C	9787 ±4.6%	Ω
at 80 °C	1704 ±2%	Ω
at 95 °C	1093 ±2.7%	Ω
at 100 °C	950 ±2.9%	Ω
$B_{25/100}$-value	3760 ±1.5%	K
Operating temperature range	−40 to +125	°C

Derating

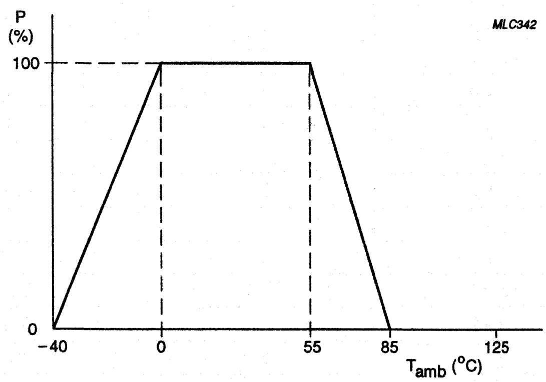


Fig.2 Power derating curve.

NTC thermistors, special accuracy 2322 640 90112

Table 1 Resistance values at intermediate temperatures

T_{amb} (°C)	RESISTANCE (Ω)	TC (%/K)	RESISTANCE TOLERANCE (%)	TEMPERATURE TOLERANCE (°C)
–40	308881	6.08	10.3	1.7
–35	229018	5.89	9.8	1.7
–30	171423	5.70	9.3	1.6
–25	129485	5.52	8.8	1.6
–20	98663	5.35	8.4	1.6
–15	75809	5.19	8.0	1.5
–10	58718	5.03	7.6	1.5
–5	45830	4.88	7.2	1.5
0	36036	4.74	6.8	1.4
5	28536	4.60	6.4	1.4
10	22751	4.47	6.0	1.3
15	18257	4.34	5.7	1.3
20	14742	4.22	5.4	1.3
25	11976	4.10	5.0	1.2
30	9787	3.98	4.6	1.1
35	8039	3.88	4.3	1.1
40	6640	3.77	4.1	1.1
45	5513	3.67	3.8	1.0
50	4600	3.57	3.5	1.0
55	3856	3.48	3.3	0.9
60	3247	3.39	3.0	0.9
65	2747	3.31	2.7	0.8
70	2333	3.22	2.5	0.8
75	1990	3.14	2.2	0.7
80	1704	3.06	2.0	0.6
85	1465	2.99	2.2	0.7
90	1264	2.92	2.5	0.8
95	1093	2.85	2.7	0.9
100	950	2.78	2.9	1.0
105	828	2.72	3.1	1.1
110	724	2.65	3.3	1.2
115	635	2.56	3.5	1.4
120	559	2.54	3.7	1.5
125	493	2.48	3.9	1.6

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	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

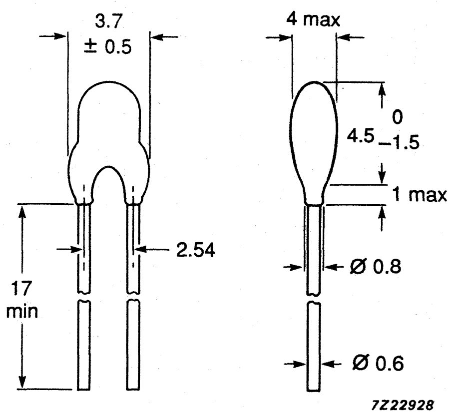


Fig.1 Component outline.

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

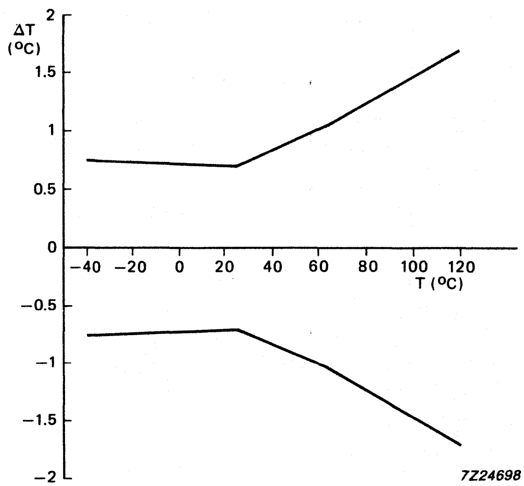


Fig.2 Tolerance curve.

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

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

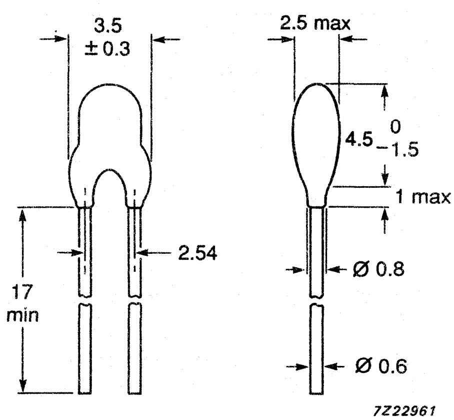


Fig.1 Component outline.

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

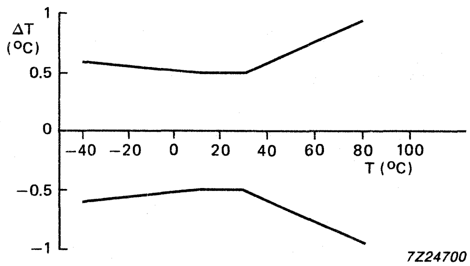


Fig.2 Tolerance curve.

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 thermistors, high-temperature sensors

2322 633 5/7/8

FEATURES

- Small diameter
- Quick response to temperature change
- High stability over a long life
- Wide temperature range from –40 to +300 °C
- Resistant to corrosive atmospheres and harsh environments.

APPLICATION

- High temperature measurement control
  - Domestic appliances
  - Automotive systems
  - Industrial process control.

DESCRIPTION

These thermistors have a negative temperature coefficient and are mounted in a glass envelope:

2322 633 5.... (SOD80) without leads and suitable for surface mounting

2322 633 7.... (SOD27) with nickel-plated leads

2322 633 8.... (SOD27) with tinned copper leads.

MECHANICAL DATA

Marking

None.

Mounting

By soldering in any position.

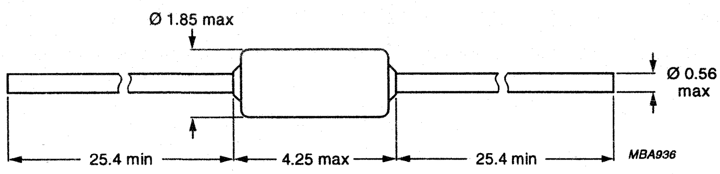
QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Temperature range:		
2322 633 5....	–40 to +200	°C
2322 633 7....	0 to 300	°C
2322 633 8....	–40 to +200	°C
Resistance value at 25 °C (R_{25})	10 to 100	kΩ
Tolerance on R_{25}-value	±5 and ±10	%
$B_{25/85}$-value	3977	K
Tolerance on $B_{25/85}$-value	±1.3	%
Rated dissipation	100	mW
Dissipation factor	2.5	mW/K
Response time	0.9	s
Thermal time constant τ	6	s
Temperature coefficient at 25 °C	–4.38	%/K
Climatic category:		
2322 633 5....	40/155/56	
2322 633 7....	0/300/56	
2322 633 8....	40/200/56	
Mass:		
2322 633 5....	≈0.03	g
2322 633 7....	≈0.14	g
2322 633 8....	≈0.14	g

NTC thermistors, high-temperature sensors

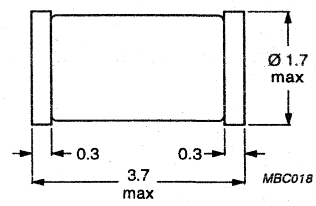
2322 633 5/7/8

Outlines



Dimensions in mm.

Fig.1 Component outline for 2322 633 7/8.... (SOD27).



Dimensions in mm.

Fig.2 Component outline for 2322 633 5.... (SOD80).

ELECTRICAL CHARACTERISTICS

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

PARAMETER	VALUE		
	2322 633 5....	2322 633 7....	2322 633 8....
$B_{25/85}$-values	3977 K		
Tolerance on B-value	±1.3%		
Ratio R_T/R_{25}	Table 2	Table 3	Table 4
Rated dissipation	100 mW		
Deviation in resistance value due to B-tolerance	Table 2	Table 3	Table 4
Temperature coefficient	Table 2	Table 3	Table 4

Table 1 R_{25}-values, $B_{25/85}$-values and catalogue numbers

The thermistors have a 12-digit catalogue number starting with 2322 633 5..../7..../8....; the subsequent 4 digits indicate the resistance value and tolerance.

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 633					
		SOD27 (leaded)				SOD80 (SMD)(2) 633 5....	
		633 8.... tinned-copper		633 7....(1) nickel-plated			
		10%	5%	10%	5%	10%	5%
10	3977 K ±1.3%	2103	3103	–	–	2103	3103
20	3977 K ±1.3%	2203	3203	–	–	2203	3203
30	3977 K ±1.3%	2303	3303	–	–	2303	3303
100	3977 K ±1.3%	2104	3104	2104	3104	2104	3104

Notes

1. 2322 633 7.... only available at 100 kΩ.
2. Only available in blister tape.

Derating

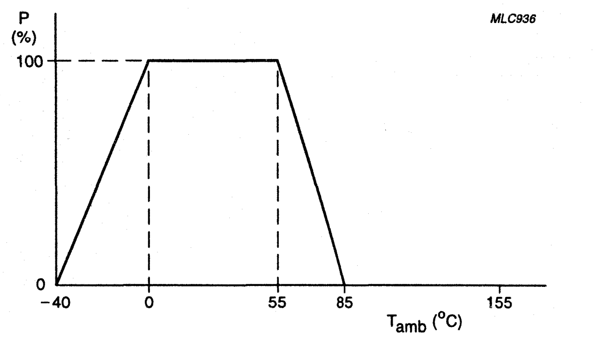


Fig.3 Derating curve for 2322 633 5.... series.

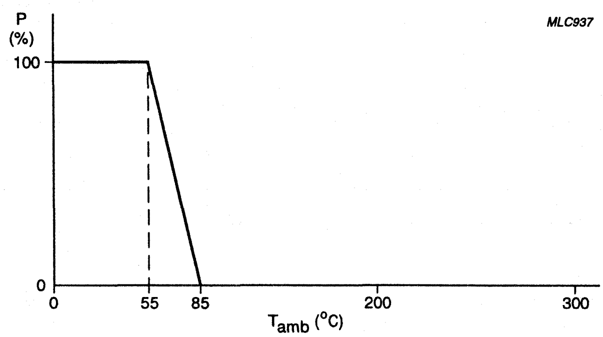


Fig.4 Derating curve for 2322 633 7.... series.

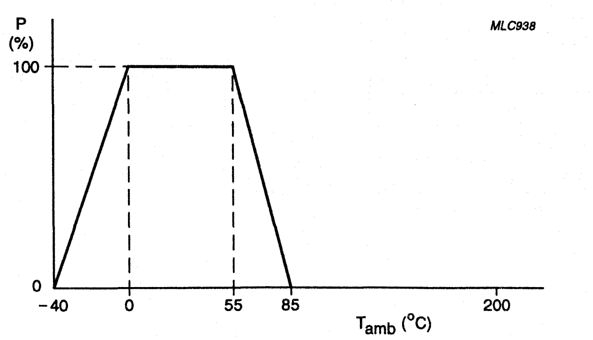


Fig.5 Derating curve for 2322 633 8.... series.

Stability and R-T characteristics

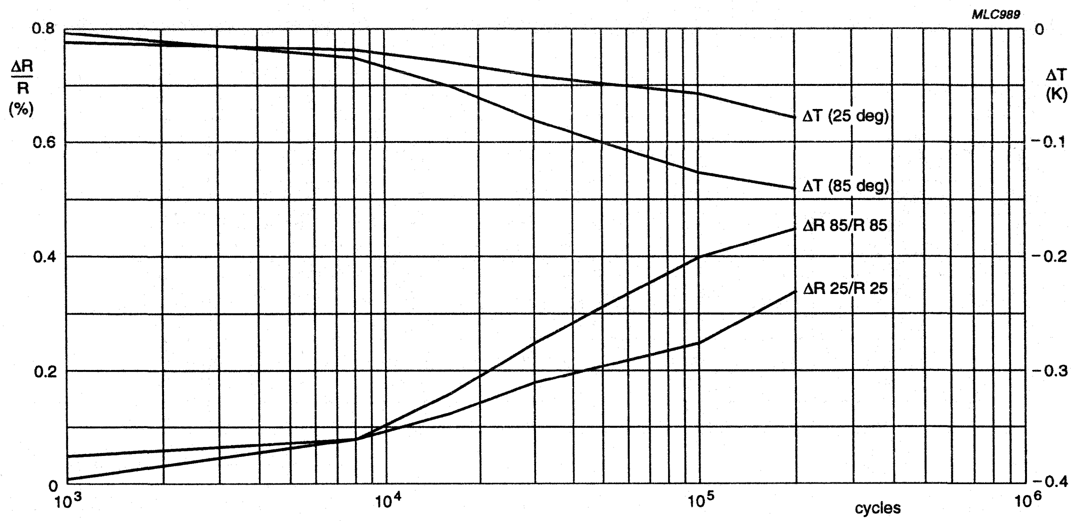


Fig.6 Stability of glass encapsulated NTCs after thermal shock test.

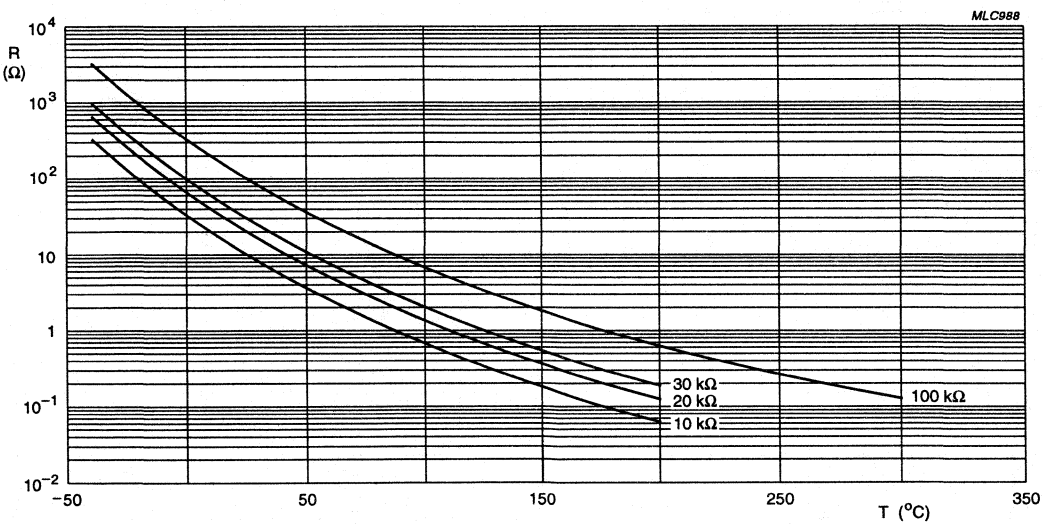


Fig.7 Typical R-T characteristics for the 2322 633 5/7/8 series.

NTC thermistors, high-temperature sensors

2322 633 5/7/8

Table 2 Resistance values at intermediate temperatures for 2322 633 5.... series

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 633 .....; see Table 4, note 1			
				5.103	**5.203**	**5.303**	**5.104**
–40	33.06	4.65	6.59	330.6	661.2	991.8	3306
–35	23.90	4.21	6.37	239.0	478.1	717.1	2390
–30	17.47	3.79	6.16	174.7	349.4	524.1	1747
–25	12.90	3.38	5.96	129.0	258.0	387.0	1290
–20	9.621	2.99	5.77	96.21	192.4	288.6	962.1
–15	7.242	2.61	5.59	72.42	144.8	217.3	724.2
–10	5.501	2.24	5.41	55.01	110.0	165.0	550.1
–5	4.214	1.89	5.24	42.14	84.28	126.4	421.4
0	3.255	1.55	5.08	32.55	65.09	97.64	325.5
5	2.534	1.22	4.93	25.34	50.67	76.01	253.4
10	1.987	0.90	4.78	19.87	39.74	59.62	198.7
15	1.570	0.59	4.64	15.70	31.40	47.10	157.0
20	1.249	0.29	4.51	12.49	24.98	37.46	124.9
25	1.000	0.00	4.38	10.00	20.00	30.00	100.0
30	0.8059	0.28	4.25	8.059	16.12	24.18	80.59
35	0.6534	0.55	4.13	6.534	13.07	19.60	65.34
40	0.5329	0.82	4.02	5.329	10.66	15.99	53.29
45	0.4371	1.08	3.91	4.371	8.742	13.11	43.71
50	0.3604	1.34	3.80	3.604	7.209	10.81	36.04
55	0.2988	1.58	3.70	2.988	5.976	8.963	29.88
60	0.2489	1.82	3.60	2.489	4.978	7.467	24.89
65	0.2084	2.06	3.51	2.084	4.168	6.251	20.84
70	0.1753	2.29	3.42	1.753	3.505	5.258	17.53
75	0.1481	2.51	3.33	1.481	2.961	4.442	14.81
80	0.1256	2.73	3.24	1.256	2.512	3.769	12.56
85	0.1070	2.95	3.16	1.070	2.141	3.211	10.70
90	0.09156	3.16	3.08	0.9156	1.831	2.747	9.156
95	0.07862	3.36	3.01	0.7862	1.572	2.359	7.862
100	0.06777	3.56	2.93	0.6777	1.355	2.033	6.777
105	0.05863	3.76	2.86	0.5863	1.173	1.759	5.863
110	0.05089	3.95	2.79	0.5089	1.018	1.527	5.089
115	0.04433	4.13	2.73	0.4433	0.8865	1.330	4.433
120	0.03873	4.32	2.66	0.3873	0.7747	1.162	3.873
125	0.03395	4.50	2.60	0.3395	0.6791	1.019	3.395
130	0.02985	4.67	2.54	0.2985	0.5971	0.8956	2.985
135	0.02633	4.84	2.49	0.2633	0.5265	0.7898	2.633
140	0.02328	5.01	2.43	0.2328	0.4656	0.6984	2.328
145	0.02065	5.17	2.38	0.2065	0.4129	0.6194	2.065
150	0.01836	5.33	2.32	0.1836	0.3671	0.5507	1.836

Table 3 Resistance values at intermediate temperatures for 2322 633 7.... series

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 633 .....; see Table 4, note 1 7.104
0	3.255	1.55	5.08	325.5
5	2.534	1.22	4.93	253.4
10	1.987	0.90	4.78	198.7
15	1.570	0.59	4.64	157.0
20	1.249	0.29	4.51	124.9
25	1.000	0.00	4.38	100.0
30	0.8059	0.28	4.25	80.59
35	0.6534	0.55	4.13	65.34
40	0.5329	0.82	4.02	53.29
45	0.4371	1.08	3.91	43.71
50	0.3604	1.34	3.80	36.04
55	0.2988	1.58	3.70	29.88
60	0.2489	1.82	3.60	24.89
65	0.2084	2.06	3.51	20.84
70	0.1753	2.29	3.42	17.53
75	0.1481	2.51	3.33	14.81
80	0.1256	2.73	3.24	12.56
85	0.1070	2.95	3.16	10.70
90	0.09156	3.16	3.08	9.156
95	0.07862	3.36	3.01	7.862
100	0.06777	3.56	2.93	6.777
105	0.05863	3.76	2.86	5.863
110	0.05089	3.95	2.79	5.089
115	0.04433	4.13	2.73	4.433
120	0.03873	4.32	2.66	3.873
125	0.03395	4.50	2.60	3.395
130	0.02985	4.67	2.54	2.985
135	0.02633	4.84	2.49	2.633
140	0.02328	2.43	2.43	2.328
145	0.02065	2.38	2.38	2.065
150	0.01836	2.32	2.32	1.836
155	0.01636	2.27	2.27	1.636
160	0.01455	2.23	2.23	1.455
165	0.01303	2.18	2.18	1.303
170	0.01169	2.14	2.14	1.169
175	0.01052	2.09	2.09	1.052

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)
				2322 633 .....; see Table 4, note 1
				7.104
180	0.00948	2.05	2.05	0.948
185	0.00857	2.01	2.01	0.857
190	0.00776	1.97	1.97	0.776
195	0.00704	1.93	1.93	0.704
200	0.00640	1.89	1.89	0.640
205	0.00575	1.87	1.87	0.575
210	0.00524	1.83	1.83	0.524
215	0.00479	1.80	1.80	0.479
220	0.00438	1.76	1.76	0.438
225	0.00402	1.73	1.73	0.402
230	0.00369	1.70	1.70	0.369
235	0.00339	1.66	1.66	0.339
240	0.00312	1.63	1.63	0.312
245	0.00288	1.60	1.60	0.288
250	0.00266	1.57	1.57	0.266
255	0.00246	1.55	1.55	0.246
260	0.00228	1.52	1.52	0.228
265	0.00211	1.49	1.49	0.211
270	0.00196	1.47	1.47	0.196
275	0.00182	1.44	1.44	0.182
280	0.00170	1.42	1.42	0.170
285	0.00158	1.39	1.39	0.158
290	0.00148	1.37	1.37	0.148
295	0.00138	1.35	1.35	0.138
300	0.00129	1.32	1.32	0.129

Table 4 Resistance values at intermediate temperatures for 2322 633 8.... series

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 633 .....; see note 1			
				8.103	8.203	8.303	8.104
–40	33.06	4.65	6.59	330.6	661.2	991.8	3306
–35	23.90	4.21	6.37	239.0	478.1	717.1	2390
–30	17.47	3.79	6.16	174.7	349.4	524.1	1747
–25	12.90	3.38	5.96	129.0	258.0	387.0	1290
–20	9.621	2.99	5.77	96.21	192.4	288.6	962.1
–15	7.242	2.61	5.59	72.42	144.8	217.3	724.2
–10	5.501	2.24	5.41	55.01	110.0	165.0	550.1
–5	4.214	1.89	5.24	42.14	84.28	126.4	421.4
0	3.255	1.55	5.08	32.55	65.09	97.64	325.5
5	2.534	1.22	4.93	25.34	50.67	76.01	253.4
10	1.987	0.90	4.78	19.87	39.74	59.62	198.7
15	1.570	0.59	4.64	15.70	31.40	47.10	157.0
20	1.249	0.29	4.51	12.49	24.98	37.46	124.9
25	1.000	0.00	4.38	10.00	20.00	30.00	100.0
30	0.8059	0.28	4.25	8.059	16.12	24.18	80.59
35	0.6534	0.55	4.13	6.534	13.07	19.60	65.34
40	0.5329	0.82	4.02	5.329	10.66	15.99	53.29
45	0.4371	1.08	3.91	4.371	8.742	13.11	43.71
50	0.3604	1.34	3.80	3.604	7.209	10.81	36.04
55	0.2988	1.58	3.70	2.988	5.976	8.963	29.88
60	0.2489	1.82	3.60	2.489	4.978	7.467	24.89
65	0.2084	2.06	3.51	2.084	4.168	6.251	20.84
70	0.1753	2.29	3.42	1.753	3.505	5.258	17.53
75	0.1481	2.51	3.33	1.481	2.961	4.442	14.81
80	0.1256	2.73	3.24	1.256	2.512	3.769	12.56
85	0.1070	2.95	3.16	1.070	2.141	3.211	10.70
90	0.09156	3.16	3.08	0.9156	1.831	2.747	9.156
95	0.07862	3.36	3.01	0.7862	1.572	2.359	7.862
100	0.06777	3.56	2.93	0.6777	1.355	2.033	6.777
105	0.05863	3.76	2.86	0.5863	1.173	1.759	5.863
110	0.05089	3.95	2.79	0.5089	1.018	1.527	5.089
115	0.04433	4.13	2.73	0.4433	0.8865	1.330	4.433
120	0.03873	4.32	2.66	0.3873	0.7747	1.162	3.873
125	0.03395	4.50	2.60	0.3395	0.6791	1.019	3.395
130	0.02985	4.67	2.54	0.2985	0.5971	0.8956	2.985
135	0.02633	4.84	2.49	0.2633	0.5265	0.7898	2.633

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)			
				2322 633 .....; see note 1			
				8.103	8.203	8.303	8.104
140	0.02328	5.01	2.43	0.2328	0.4656	0.6984	2.328
145	0.02065	5.17	2.38	0.2065	0.4129	0.6194	2.065
150	0.01836	5.33	2.32	0.1836	0.3671	0.5507	1.836
155	0.01636	5.49	2.27	0.1636	0.3273	0.4909	1.636
160	0.01455	5.65	2.23	0.1455	0.2910	0.4365	1.455
165	0.01303	5.80	2.18	0.1303	0.2606	0.3909	1.303
170	0.01169	5.95	2.14	0.1169	0.2339	0.3508	1.169
175	0.01052	6.10	2.09	0.1052	0.2104	0.3156	1.052
180	0.00948	6.24	2.05	0.09484	0.1897	0.2845	0.9484
185	0.00857	6.38	2.01	0.08569	0.1714	0.2571	0.8569
190	0.00776	6.52	1.97	0.07757	0.1551	0.2327	0.7757
195	0.00704	6.66	1.93	0.07037	0.1407	0.2111	0.7037
200	0.00640	6.79	1.89	0.06396	0.1279	0.1919	0.6396

Note

1. Replace dot in code number by a number according to the following list and depending on tolerance on required R_{25}-value:
   a) 3 for a tolerance of ±5%.
   b) 2 for a tolerance of ±10%.

PACKAGING AND ORDERING INFORMATION

Table 5 Catalogue numbers and packaging quantities

CATALOGUE NUMBER	BULK	BLISTER	TAPE
2322 633 3....; note 1	–	–	10000
2322 633 4....; note 2	–	–	10000
2322 633 5....	–	2500	–
2322 633 7....	1000	–	–
2322 633 8....	1000	–	–

Notes

1. Catalogue number 2322 633 3.... is the series 2322 633 8.... on tape.
2. Catalogue number 2322 633 4.... is the series 2322 633 7.... on tape.

NTC thermistors, high-temperature sensors

2322 633 5/7/8

Blister tape, reel and bandolier data

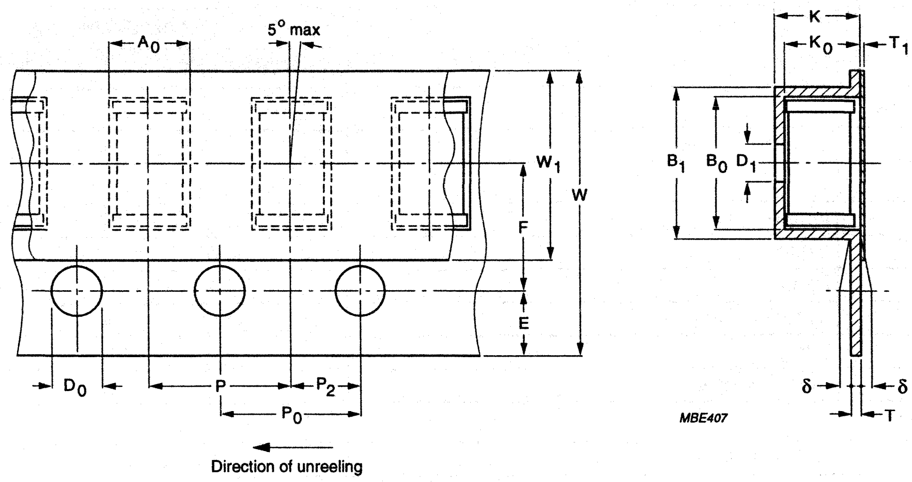


Fig.8 Blister tape.

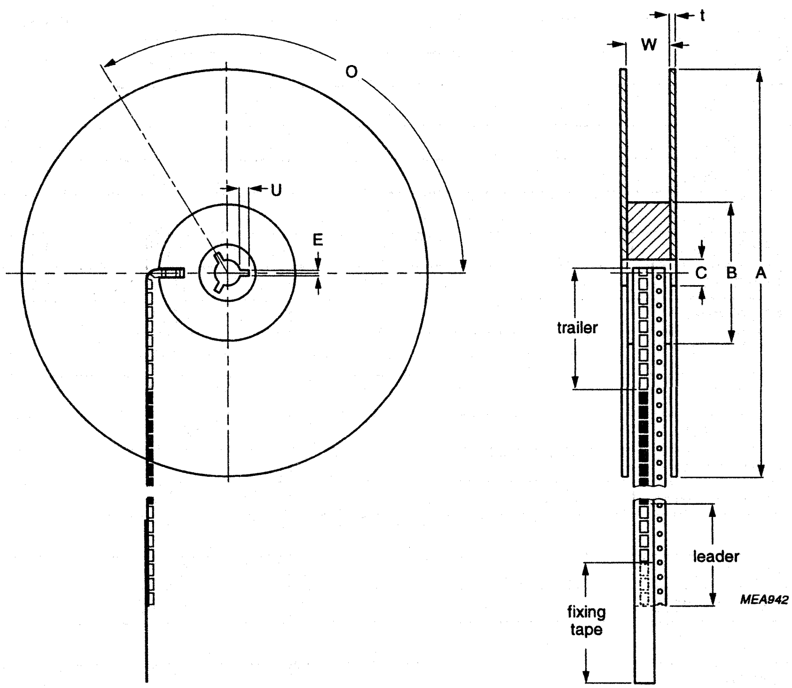
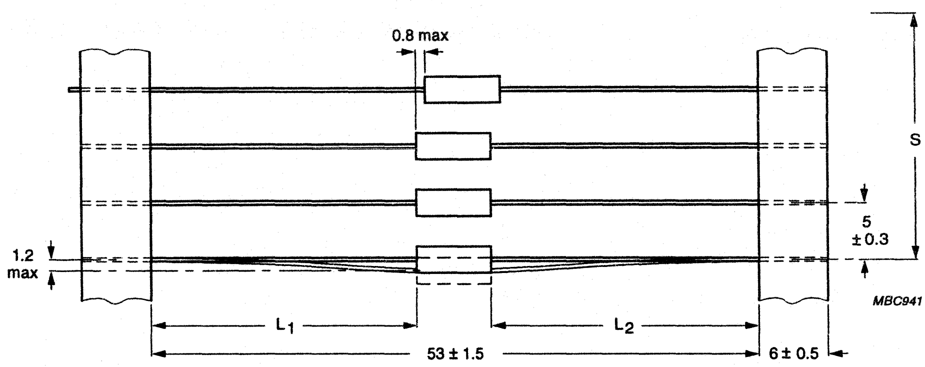


Fig.9 Reel.

Table 6 Blister tape and reel dimensions
Dimensions in mm unless otherwise stated; see Figs 8 and 9.

SYMBOL	PARAMETER	DIMENSIONS (mm)	
		NOMINAL	TOLERANCE
Blister tape			
K	overall thickness	<2.5	–
POCKET			
A_0	length	2.1	+0.3
B_0	width	>3.8	–
K_0	depth	2.1	+0.3
B_1	outside width	<4.5	–
P	pitch	4.0	±0.1
D_1	hole diameter	1.0	±0.1
FEED-HOLE			
D_0	diameter	1.5	±0.1
P_0	pitch	4.0	±0.1
E	distance	1.75	±0.1
	cumulative pitch error over 10 positions	0	±0.1
CENTRE LINE			
P_2	length	2.0	±0.05
F	width	3.5	±0.1
FIXING TAPE			
W_1	width	<5.5	–
T_1	thickness	<0.1	–
CARRIER TAPE			
W	thickness	8.0	±0.2
δ	bending	<0.3	–
T	thickness	<0.4	–
Reel			
FLANGE			
A	diameter	180	+0
t	thickness	1.5	+0.5
W	space between flanges	9.5	±0.5
HUB			
B	diameter	62.0	±1.5
C	spindle hole	12.75	+0.15/–0
KEY SLIT			
E	width	2.0	±0.5
U	depth	4.0	±0.5
O	location	120°	–



A black marker is printed on the tape of the bandolier after every 50 units.
The components are centred so that $|L_1 - L_2| = 1.2$ mm. max.
The cumulative space (S) measured over 10 spacings = 50 ±2 mm.

Fig.10 Thermistors on bandolier.

Note to Table 6 and Fig.10

The bandolier of a 180 mm reel contains at least 2500 devices with no more than 0.5% empty positions. Three consecutive empty places may be found provided this gap is followed by 6 consecutive devices.
The carrier tape starts (leader) and ends (trailer) with at least 75 empty positions (equivalent to 300 mm); the covering foil is at least 300 mm. In order to fix the carrier tape a self-adhesive tape of 20 to 50 mm width is applied.

NTC THERMISTORS
SOD27 range

TEMPERATURE SENSING AND CONTROL

Features

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

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

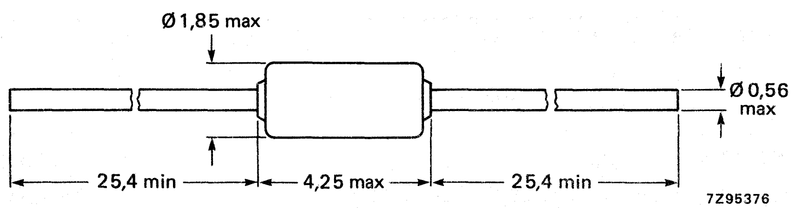


Fig.1 Component outline; SOD27.

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.

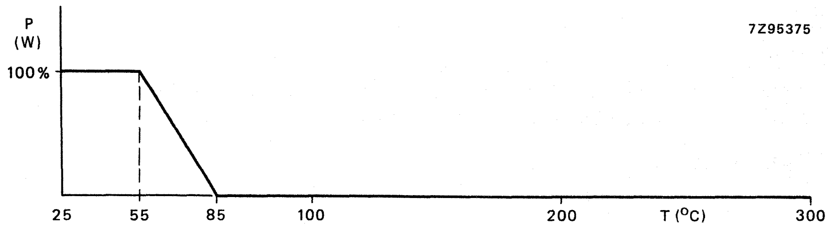


Fig. 2 Derating curve.

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

NTC THERMISTORS

glass encapsulated miniature bead

TEMPERATURE SENSING AND CONTROL

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

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

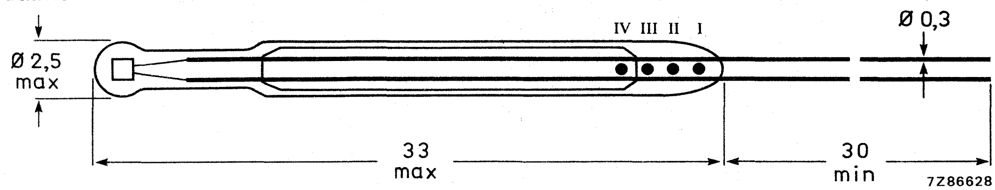
Temperature measurement and control up to 300 °C in 'aggressive' environments. Also level sensing.

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).

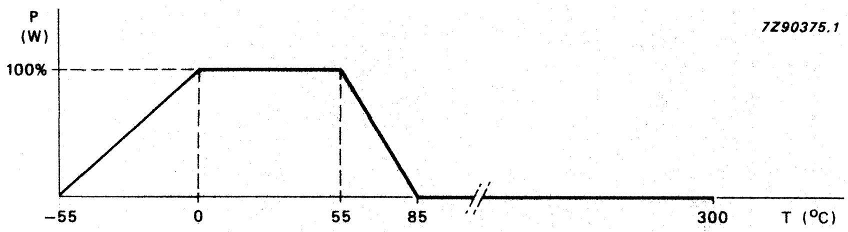


Fig.2 Derating curve.

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.

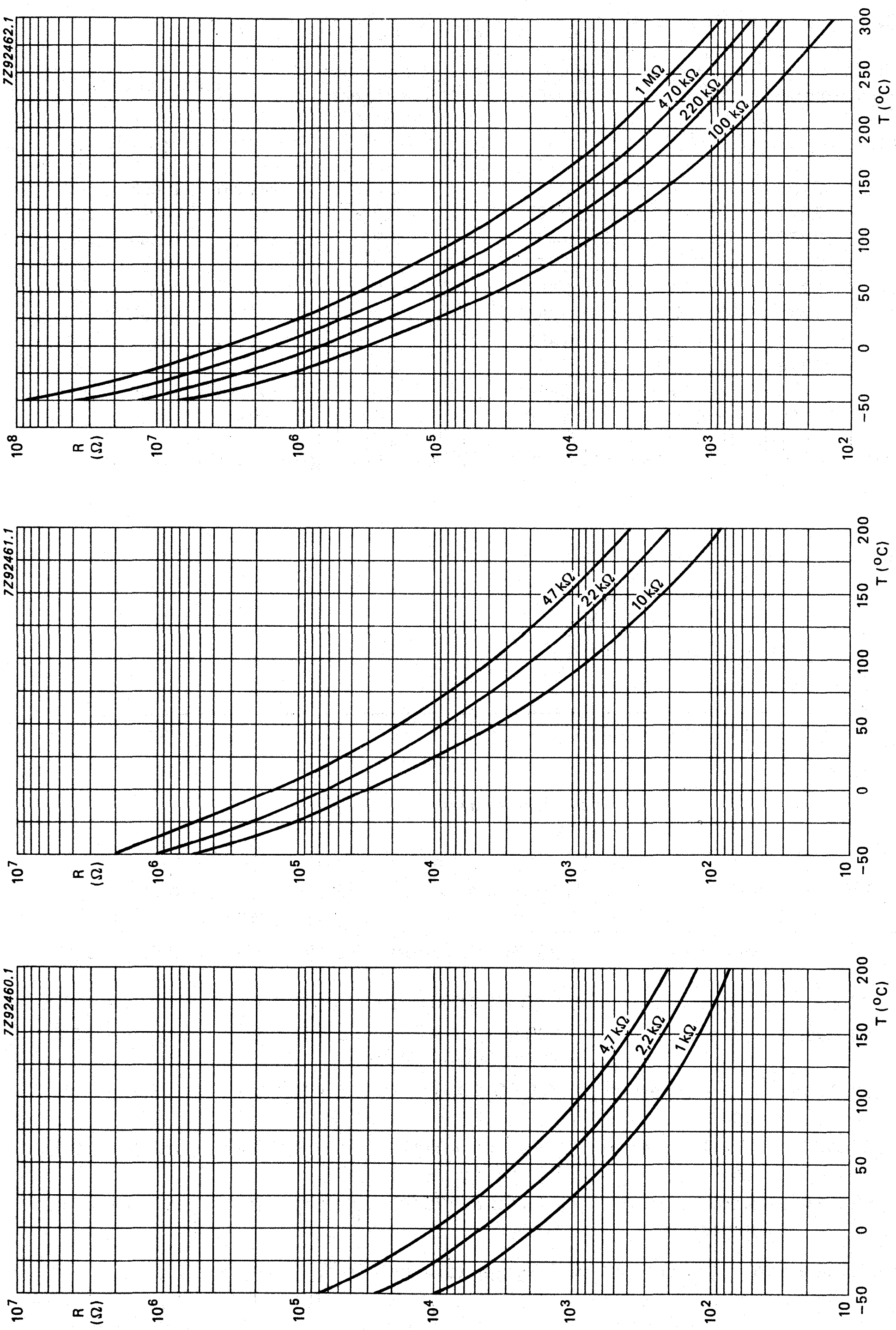


Fig.3 Typical resistance/temperature characteristics.

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

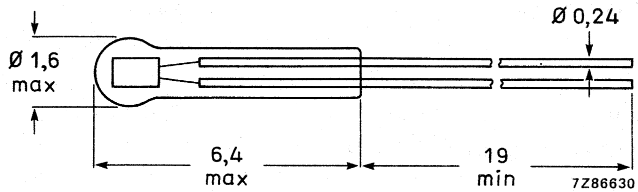


Fig.1 Component outline.

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.

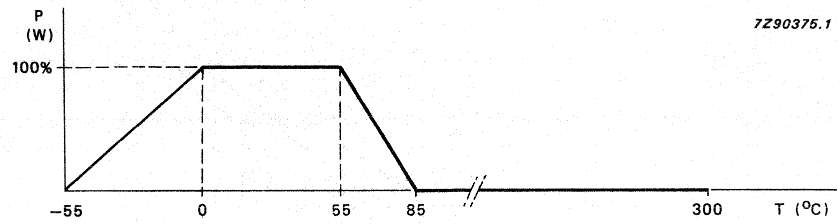
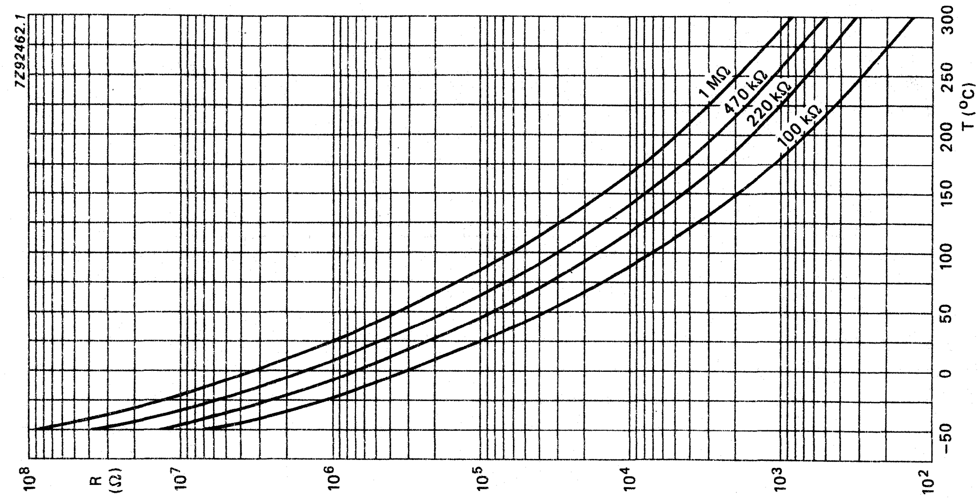


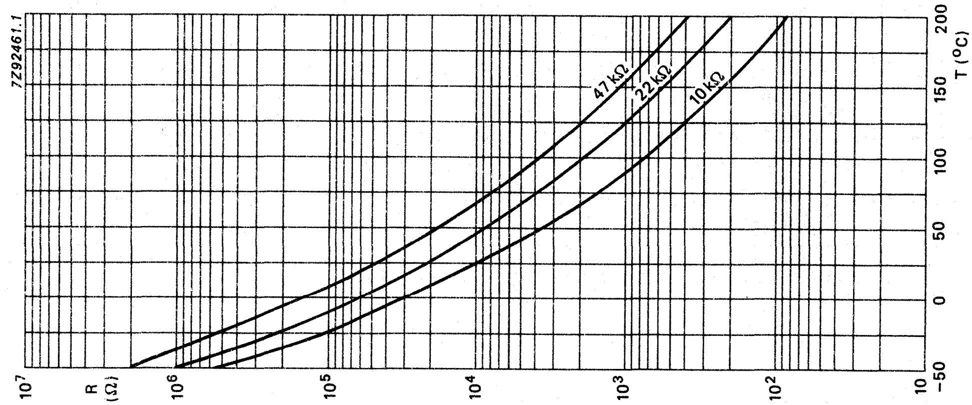
Fig.2 Derating curve.

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.





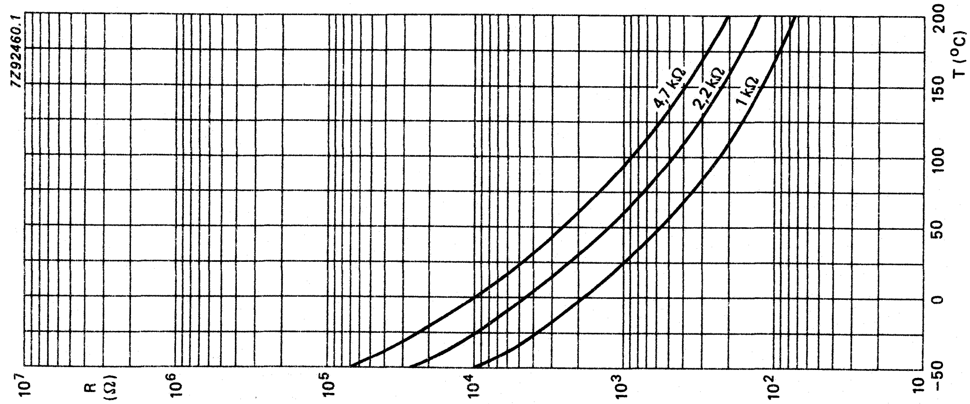


Fig.3 Typical resistance/temperature characteristics.

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

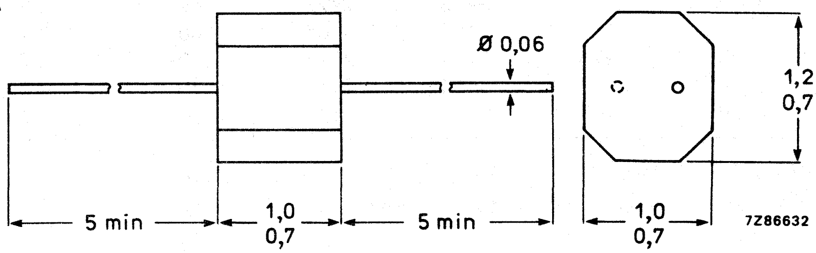


Fig.1
version 2322 633 0....
(axial leads).

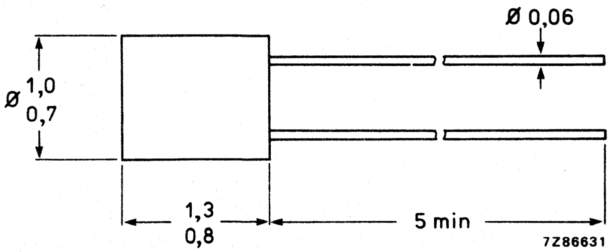


Fig.2
version 2322 633 1....
(radial leads).

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	−4.3	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	30 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.

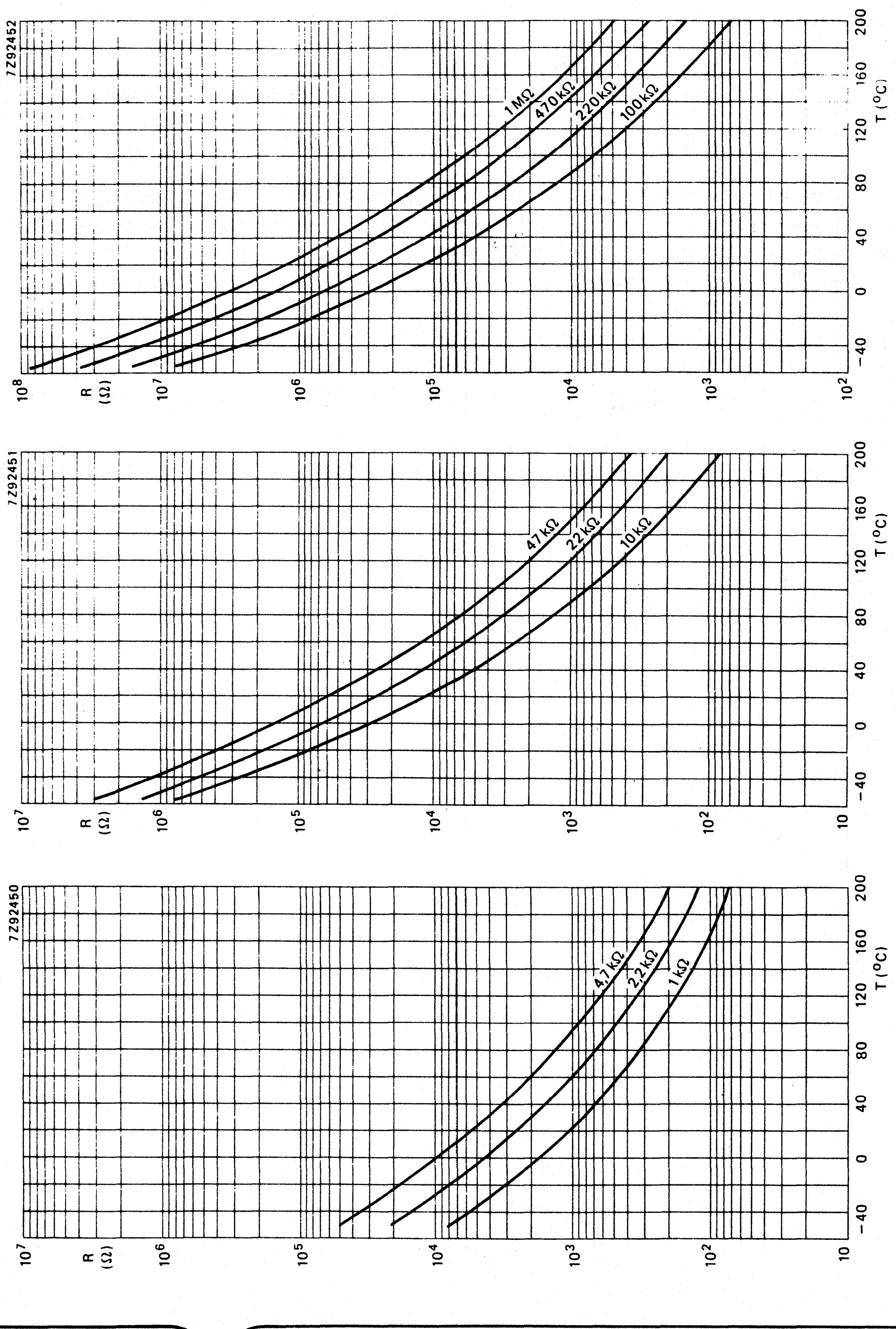


Fig.3 Typical resistance/temperature characteristics.

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

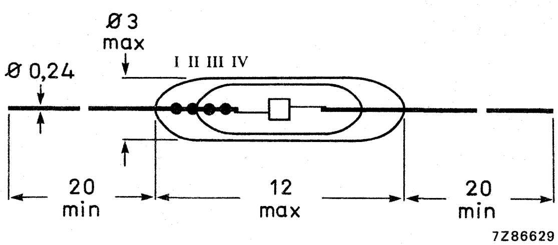


Fig.1 Component outline.

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

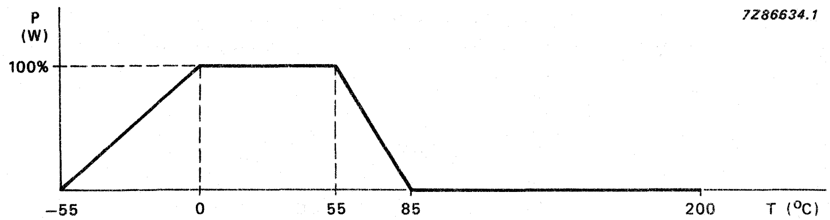


Fig.2 Derating curve.

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 ....

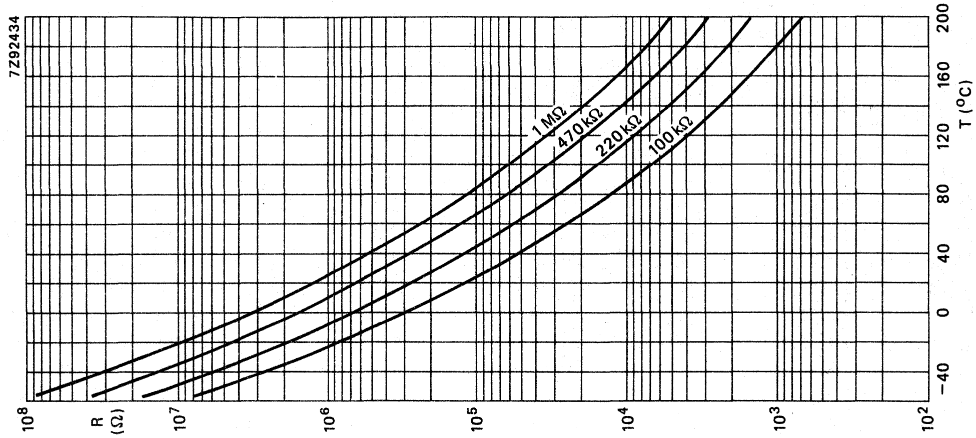
suffix of the catalogue number		R_{25}	$B_{25/85}$-value ± 5%	temperature coefficient at 25 °C	colour code*		
tol. ± 5%	tol. ± 10%	kΩ	K	%/K	I	II	III
3102	2102	1	2075	−2.3	brown	black	red
3222	2222	2.2	2285	−2.6	red	red	red
3472	2472	4.7	2485	−2.8	yellow	violet	red
3103	2103	10	3750	−4.2	brown	black	orange
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

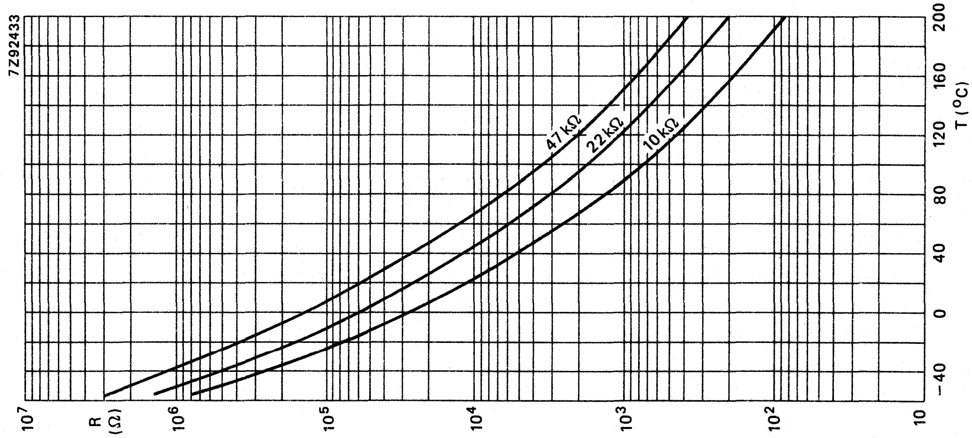
* Thermistors with 5% tolerance have a gold dot IV; 10% tolerance is identified by a silver dot IV, (Fig.1).

Table 2 Stability data

CECC	IEC	test	procedure	drift (requirement)	drift (typical)*
D3 4.20.1		endurance	25 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.1\%$
	68-2-1	endurance	−40 °C, 1000 hours	$\Delta R/R < 1\%$	$\Delta R/R = 0.15\%$
	539-gen	endurance	60 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	$\Delta R/R < 2\%$	$\Delta R/R = 0.1\%$

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





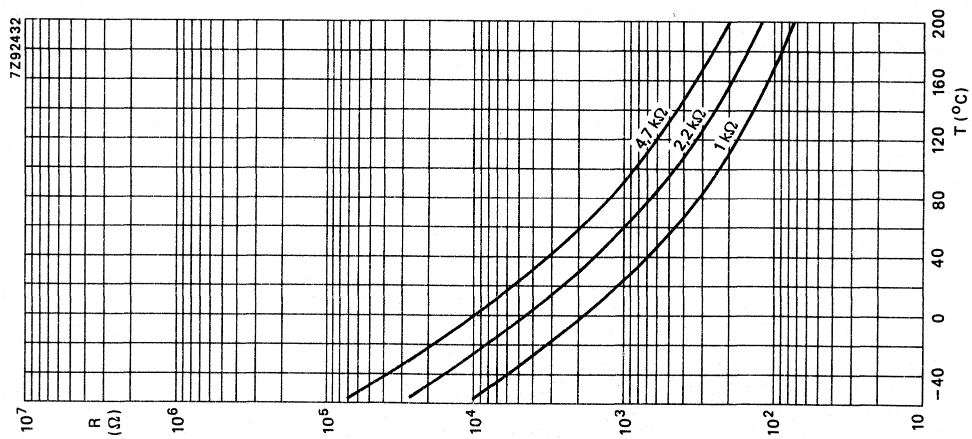


Fig.3 Typical resistance/temperature characteristics.

NTC thermistors, naked chips

2322 640 0....

FEATURES

- Accurate over a wide temperature range
- High stability (tolerance on B-value between ±2.5% and ±0.75%) over a long life
- Excellent price/performance ratio
- For mechanical fixing in a housing or soldering directly to 'non-standard' leads.

APPLICATION

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a metallized square chip.

PACKAGING

The naked chips are placed in sealed polythene bags and packed in cardboard boxes. The smallest packing quantity is 5000 units.

MECHANICAL DATA

Marking

None.

Mounting

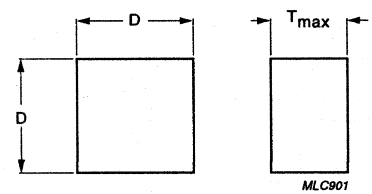
By reflow or wave soldering in any position or mechanical fixing.

The use of ultrasonic soldering is **not** recommended.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	2.2 to 470	kΩ
Tolerance on R_{25}-value	±1; ±2; ±3; ±5	%
$B_{25/85}$-value	3740 to 4570	K
Tolerance on $B_{25/85}$-value	±2.5 to ±0.75	%
Maximum dissipation	500	mW
Response time	<1.2	s
Climatic category	40/125/56	
Mass	see Table 1	

Outline



For dimensions see Table 1.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	2.2 to 470	kΩ
Standard selection tolerances	±1; ±2; ±3; ±5	%
Climatic category	40/125/56	
Maximum dissipation	500	mW
Operating temperature range:		
at zero dissipation (continuously)	−40 to +125	°C
for short periods	≤150	°C
at maximum dissipation	0 to +55	°C

Derating

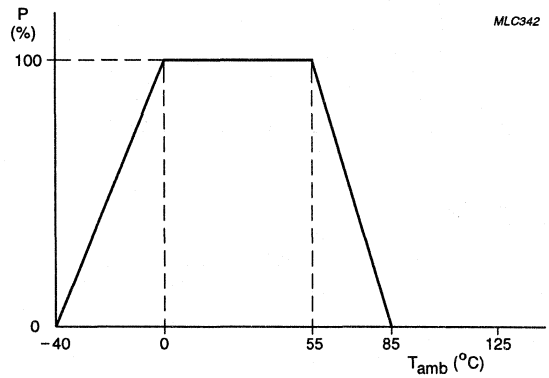


Fig.2 Power derating curve.

NTC thermistors, naked chips 2322 640 0....

Table 1 R_{25}-values, TC, mass, dimensions and catalogue numbers

R_{25} (Ω)	TC (%/K)	MASS (g)	D (mm)	$T_{max.}$ (mm)	$B_{25/85}$		CATALOGUE NUMBER 2322 640(1)
					K	TOL. (%)	
2200	4.37	0.016	2.3 ±0.4	1.3	3977	±0.75	0.222
2700	4.37	0.014	2.3 ±0.4		3977	±0.75	0.272
3300	4.37	0.011	2.0 ±0.4		3977	±0.75	0.332
4700	4.37	0.008	2.0 ±0.4		3977	±0.75	0.472
5000	4.37	0.008	2.0 ±0.4		3977	±0.75	0.502
6000	4.37	0.008	2.0 ±0.4		3977	±0.75	0.602
6800	4.37	0.011	2.0 ±0.4		3977	±0.75	0.682
8000	4.37	0.011	2.0 ±0.4		3977	±0.75	0.802
10000	4.37	0.016	2.0 ±0.4		3977	±0.75	0.103
12000	4.10	0.014	2.0 ±0.4		3740	±2.0	0.123
15000	4.10	0.011	2.0 ±0.4		3740	±2.0	0.153
22000	4.10	0.008	2.0 ±0.4		3740	±2.0	0.223
33000	4.46	0.011	2.0 ±0.4		4090	±1.5	0.333
47000	4.46	0.016	2.0 ±0.4		4090	±1.5	0.473
68000	4.57	0.012	2.0 ±0.4		4190	±1.5	0.683
100000	4.57	0.008	2.0 ±0.4		4190	±1.5	0.104
150000	4.75	0.011	2.0 ±0.4		4370	±2.5	0.154
220000	4.75	0.008	2.0 ±0.4		4370	±2.5	0.224
330000	4.95	0.014	2.0 ±0.4		4570	±1.5	0.334
470000	4.95	0.014	2.0 ±0.4		4570	±1.5	0.474

Note

1. Replace dot in last 5 digits of catalogue number by a number according to the following list and depending on tolerance on required R_{25}-value:
   a) 5 for a tolerance of ±1%
   b) 4 for a tolerance of ±2%
   c) 6 for a tolerance of ±3%
   d) 3 for a tolerance of ±5%.

Table 2 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 1, note 1			
				0.222	0.272	0.332	0.472
−40	33.21	2.66	6.57	73.06	89.67	109.6	156.1
−35	23.99	2.41	6.36	52.78	64.77	79.17	112.8
−30	17.52	2.17	6.15	38.55	47.31	57.82	82.35
−25	12.93	1.94	5.95	28.44	34.91	42.67	60.77
−20	9.636	1.71	5.76	21.20	26.02	31.80	45.30
−15	7.250	1.50	5.58	15.95	19.58	23.93	34.08
−10	5.505	1.29	5.40	12.11	14.86	18.16	25.87
−5	4.216	1.08	5.24	9.275	11.38	13.91	19.81
0	3.255	0.89	5.08	7.162	8.790	10.74	15.30
5	2.534	0.70	4.92	5.575	6.842	8.362	11.91
10	1.987	0.52	4.78	4.372	5.366	6.558	9.340
15	1.570	0.34	4.64	3.454	4.239	5.181	7.378
20	1.249	0.17	4.50	2.747	3.372	4.121	5.869
25	1.000	0.00	4.37	2.200	2.700	3.300	4.700
30	0.8059	0.16	4.25	1.773	2.176	2.660	3.788
35	0.6535	0.32	4.13	1.438	1.764	2.156	3.072
40	0.5330	0.47	4.02	1.173	1.439	1.759	2.505
45	0.4372	0.62	3.91	0.9618	1.180	1.443	2.055
50	0.3605	0.77	3.80	0.7932	0.973	1.190	1.694
55	0.2989	0.91	3.70	0.6575	0.807	0.9863	1.405
60	0.2490	1.05	3.60	0.5478	0.672	0.8217	1.170
65	0.2084	1.18	3.51	0.4586	0.562	0.6879	0.9797
70	0.1753	1.31	3.42	0.3857	0.473	0.5785	0.8239
75	0.1481	1.44	3.33	0.3258	0.399	0.4887	0.6960
80	0.1256	1.57	3.25	0.2764	0.339	0.4146	0.5905
85	0.1070	1.69	3.16	0.2355	0.289	0.3532	0.5031
90	0.09154	1.81	3.09	0.2014	0.247	0.3021	0.4303
95	0.07860	1.93	3.01	0.1729	0.212	0.2594	0.3694
100	0.06773	2.04	2.94	0.1490	0.182	0.2235	0.3183
105	0.05858	2.15	2.87	0.1289	0.158	0.1933	0.2753
110	0.05083	2.26	2.80	0.1118	0.137	0.1677	0.2389
115	0.04426	2.37	2.73	0.0974	0.1195	0.1461	0.2080
120	0.03866	2.47	2.67	0.0851	0.1044	0.1276	0.1817
125	0.03387	2.57	2.61	0.0745	0.0915	0.1118	0.1592
130	0.02977	2.67	2.55	0.0655	0.0804	0.0982	0.1399
135	0.02624	2.77	2.49	0.0577	0.0709	0.0866	0.1233
140	0.02319	2.86	2.43	0.0510	0.0626	0.0765	0.1090
145	0.02055	2.96	2.38	0.0452	0.0555	0.0678	0.0966
150	0.01826	3.05	2.33	0.0402	0.0493	0.0603	0.0858

NTC thermistors, naked chips 2322 640 0....

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 1, note 1				
				0.502	**0.602**	**0.682**	**0.802**	**0.103**
−40	33.21	2.66	6.57	166.1	199.3	225.8	265.7	332.1
−35	23.99	2.41	6.36	120.0	143.9	163.1	191.9	240.0
−30	17.52	2.17	6.15	87.60	105.1	119.1	140.2	175.2
−25	12.93	1.94	5.95	64.65	77.57	87.92	103.4	129.3
−20	9.636	1.71	5.76	48.18	57.82	65.53	77.09	96.36
−15	7.250	1.50	5.58	36.25	43.50	49.30	58.00	72.50
−10	5.505	1.29	5.40	27.52	33.03	37.43	44.04	55.05
−5	4.216	1.08	5.24	21.08	25.30	28.67	33.73	42.16
0	3.255	0.89	5.08	16.28	19.53	22.14	26.04	32.56
5	2.534	0.70	4.92	12.67	15.20	17.23	20.27	25.34
10	1.987	0.52	4.78	9.936	11.92	13.51	15.90	19.87
15	1.570	0.34	4.64	7.849	9.419	10.67	12.56	15.70
20	1.249	0.17	4.50	6.244	7.493	8.492	9.990	12.49
25	1.000	0.00	4.37	5.000	6.000	6.800	8.000	10.00
30	0.8059	0.16	4.25	4.030	4.836	5.480	6.447	8.059
35	0.6535	0.32	4.13	3.267	3.921	4.444	5.228	6.535
40	0.5330	0.47	4.02	2.665	3.198	3.624	4.264	5.330
45	0.4372	0.62	3.91	2.186	2.623	2.972	3.497	4.372
50	0.3605	0.77	3.80	1.803	2.163	2.451	2.884	3.606
55	0.2989	0.91	3.70	1.494	1.793	2.032	2.391	2.989
60	0.2490	1.05	3.60	1.245	1.494	1.693	1.992	2.490
65	0.2084	1.18	3.51	1.042	1.251	1.417	1.668	2.084
70	0.1753	1.31	3.42	0.8765	1.052	1.192	1.402	1.753
75	0.1481	1.44	3.33	0.7405	0.8886	1.007	1.185	1.481
80	0.1256	1.57	3.25	0.6282	0.7538	0.8544	1.005	1.256
85	0.1070	1.69	3.16	0.5352	0.6422	0.7278	0.8563	1.070
90	0.09154	1.81	3.09	0.4577	0.5493	0.6225	0.7324	0.9154
95	0.07860	1.93	3.01	0.3930	0.4716	0.5345	0.6288	0.7860
100	0.06773	2.04	2.94	0.3387	0.4064	0.4607	0.5419	0.6773
105	0.05858	2.15	2.87	0.2929	0.3515	0.3983	0.4686	0.5858
110	0.05083	2.26	2.80	0.2542	0.3050	0.3457	0.4067	0.5083
115	0.04426	2.37	2.73	0.2213	0.2656	0.3010	0.3541	0.4426
120	0.03866	2.47	2.67	0.1933	0.2320	0.2629	0.3093	0.3866
125	0.03387	2.57	2.61	0.1694	0.2032	0.2303	0.2710	0.3387
130	0.02977	2.67	2.55	0.1488	0.1786	0.2024	0.2382	0.2977
135	0.02624	2.77	2.49	0.1312	0.1574	0.1784	0.2099	0.2624
140	0.02319	2.86	2.43	0.1160	0.1391	0.1577	0.1855	0.2319
145	0.02055	2.96	2.38	0.1028	0.1233	0.1398	0.1644	0.2055
150	0.01826	3.05	2.33	0.0913	0.1096	0.1242	0.1461	0.1826

NTC thermistors, naked chips 2322 640 0....

Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 1, note 1		
				0.123	**0.153**	**0.223**
–40	25.78	6.81	6.09	309.4	386.8	567.2
–35	19.13	6.16	5.89	229.5	286.9	420.8
–30	14.32	5.53	5.70	171.8	214.8	315.0
–25	10.82	4.93	5.52	129.8	162.3	238.0
–20	8.245	4.35	5.35	98.93	123.7	181.4
–15	6.335	3.80	5.19	76.02	95.03	139.4
–10	4.907	3.26	5.03	58.88	73.60	107.9
–5	3.830	2.74	4.88	45.95	57.44	84.25
0	3.011	2.24	4.73	36.13	45.16	66.24
5	2.384	1.76	4.60	28.60	35.76	52.45
10	1.900	1.30	4.46	22.80	28.50	41.81
15	1.525	0.85	4.34	18.30	22.87	33.55
20	1.231	0.42	4.21	14.77	18.47	27.09
25	1.000	0.00	4.10	12.00	15.00	22.00
30	0.8170	0.41	3.98	9.804	12.26	17.97
35	0.6712	0.80	3.88	8.054	10.07	14.77
40	0.5543	1.19	3.77	6.652	8.315	12.20
45	0.4602	1.57	3.67	5.522	6.903	10.12
50	0.3839	1.94	3.57	4.607	5.759	8.447
55	0.3219	2.30	3.48	3.862	4.828	7.081
60	0.2710	2.65	3.39	3.252	4.067	5.963
65	0.2293	2.99	3.30	2.751	3.439	5.044
70	0.1947	3.33	3.22	2.337	2.921	4.284
75	0.1661	3.66	3.14	1.993	2.492	3.654
80	0.1422	3.98	3.06	1.707	2.134	3.129
85	0.1223	4.29	2.99	1.467	1.834	2.690
90	0.1055	4.60	2.92	1.266	1.583	2.321
95	0.09135	4.90	2.85	1.096	1.370	2.010
100	0.07937	5.19	2.78	0.9524	1.190	1.746
105	0.06919	5.48	2.71	0.8302	1.038	1.522
110	0.06050	5.76	2.65	0.7260	0.9075	1.331
115	0.05307	6.04	2.59	0.6369	0.7961	1.168
120	0.04670	6.31	2.53	0.5604	0.7005	1.027
125	0.04121	6.57	2.47	0.4945	0.6181	0.9065

NTC thermistors, naked chips 2322 640 0....

Table 5 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 1, note 1	
				0.333	**0.473**
−40	33.81	5.55	6.55	1116	1589
−35	24.50	5.02	6.34	808.6	1151
−30	17.93	4.52	6.15	591.7	842.8
−25	13.25	4.03	5.96	437.1	622.6
−20	9.875	3.56	5.78	325.9	464.1
−15	7.425	3.10	5.61	245.0	349.0
−10	5.630	2.67	5.45	185.8	264.6
−5	4.304	2.24	5.29	142.0	202.3
0	3.315	1.84	5.14	109.4	155.8
5	2.573	1.44	4.99	84.91	120.9
10	2.011	1.07	4.85	66.37	94.53
15	1.583	0.70	4.72	52.24	74.40
20	1.254	0.34	4.59	41.39	58.95
25	1.000	0.00	4.46	33.00	47.00
30	0.8024	0.33	4.34	26.47	37.71
35	0.6474	0.66	4.23	21.37	30.43
40	0.5255	0.98	4.12	17.34	24.70
45	0.4288	1.28	4.01	14.15	20.15
50	0.3518	1.59	3.91	11.61	16.53
55	0.2901	1.88	3.81	9.572	13.63
60	0.2403	2.17	3.71	7.931	11.30
65	0.2001	2.45	3.62	6.603	9.404
70	0.1674	2.72	3.53	5.522	7.865
75	0.1406	2.99	3.44	4.639	6.607
80	0.1186	3.25	3.36	3.913	5.573
85	0.1004	3.51	3.28	3.315	4.721
90	0.08542	3.76	3.20	2.819	4.015
95	0.07292	4.00	3.13	2.406	3.427
100	0.06248	4.24	3.06	2.062	2.936
105	0.05372	4.47	2.98	1.773	2.525
110	0.04635	4.70	2.92	1.530	2.179
115	0.04013	4.93	2.85	1.342	1.886
120	0.03485	5.15	2.79	1.150	1.638
125	0.03037	5.36	2.73	1.002	1.427
130	0.02654	5.57	2.67	0.8757	1.247
135	0.02326	5.78	2.61	0.7675	1.093
140	0.02044	5.98	2.55	0.6746	0.9608
145	0.01802	6.18	2.50	0.5945	0.8468
150	0.01592	6.37	2.44	0.5254	0.7483

NTC thermistors, naked chips 2322 640 0....

Table 6 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 640 .....; see Table 1, note 1	
				0.683	**0.104**
−40	36.66	5.69	6.70	2493	3666
−35	26.38	5.15	6.49	1794	2638
−30	19.17	4.63	6.29	1303	1917
−25	14.06	4.13	6.10	956.2	1406
−20	10.41	3.65	5.92	708.0	1041
−15	7.779	3.18	5.74	528.9	777.9
−10	5.861	2.73	5.57	398.5	586.1
−5	4.453	2.30	5.41	302.8	445.3
0	3.409	1.88	5.26	231.8	340.9
5	2.631	1.48	5.11	178.9	263.1
10	2.044	1.09	4.97	139.0	204.4
15	1.600	0.72	4.83	108.8	160.0
20	1.261	0.35	4.70	85.74	126.1
25	1.000	0.00	4.57	68.00	100.0
30	0.7981	0.34	4.45	54.27	79.81
35	0.6408	0.67	4.35	43.57	64.08
40	0.5175	1.00	4.22	35.19	51.74
45	0.4202	1.32	4.11	28.57	42.02
50	0.3431	1.63	4.00	23.33	34.31
55	0.2816	1.93	3.90	19.15	28.16
60	0.2322	2.22	3.80	15.79	23.22
65	0.1925	2.51	3.71	13.09	19.25
70	0.1602	2.79	3.62	10.90	16.03
75	0.1340	3.06	3.53	9.114	13.40
80	0.1126	3.33	3.45	7.655	11.26
85	0.09496	3.59	3.36	6.457	9.496
90	0.08042	3.85	3.28	5.469	8.042
95	0.06837	4.10	3.21	4.649	6.837
100	0.05835	4.35	3.13	3.968	5.835
105	0.04998	4.59	3.06	3.399	4.998
110	0.04296	4.82	2.99	2.921	4.296
115	0.03705	5.05	2.92	2.519	3.705
120	0.03206	5.28	2.86	2.180	3.206
125	0.02783	5.50	2.80	1.892	2.783

NTC thermistors, naked chips 2322 640 0....

Table 7 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)	
				2322 640 .....; see Table 1, note 1	
				0.154	**0.224**
−40	41.02	10.10	6.89	6153	9024
−35	29.29	9.12	6.68	4394	6444
−30	21.12	8.18	6.48	3168	4646
−25	15.37	7.28	6.29	2305	3381
−20	11.28	6.42	6.11	1693	2483
−15	8.358	5.59	5.93	1254	1839
−10	6.242	4.80	5.76	936.4	1373
−5	4.700	4.03	5.60	705.0	1034
0	3.567	3.30	5.44	535.0	784.7
5	2.727	2.59	5.29	409.1	600.0
10	2.101	1.90	5.15	315.1	462.1
15	1.629	1.25	5.01	244.4	358.4
20	1.272	0.61	4.88	190.8	279.9
25	1.000	0.00	4.75	150.0	220.0
30	0.7910	0.59	4.62	118.6	174.0
35	0.6295	1.18	4.51	94.42	138.5
40	0.5039	1.74	4.39	75.58	110.9
45	0.4056	2.30	4.28	60.85	89.24
50	0.3283	2.84	4.17	49.25	72.24
55	0.2672	3.37	4.07	40.08	58.78
60	0.2185	3.89	3.97	32.78	48.08
65	0.1796	4.40	3.87	26.94	39.51
70	0.1483	4.90	3.78	22.25	32.63
75	0.1231	5.39	3.69	18.46	27.07
80	0.1025	5.86	3.60	15.38	22.56
85	0.08582	6.33	3.52	12.87	18.88
90	0.07213	6.79	3.44	10.82	15.87
95	0.06086	7.24	3.36	9.129	13.39
100	0.05155	7.68	3.28	7.732	11.34
105	0.04383	8.11	3.21	6.574	9.642
110	0.03740	8.53	3.14	5.610	8.228
115	0.03203	8.94	3.07	4.804	7.046
120	0.02752	9.35	3.00	4.128	6.054
125	0.02372	9.75	2.94	3.559	5.219

NTC thermistors, naked chips 2322 640 0....

Table 8 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)	
				2322 640 .....; see Table 1, note 1	
				0.334	0.474
−40	48.62	6.22	7.13	16044	22850
−35	34.19	5.63	6.91	11282	16068
−30	24.28	5.06	6.71	8013	11413
−25	17.42	4.51	6.52	5747	8185
−20	12.61	3.98	6.33	4161	5926
−15	9.211	3.47	6.15	3040	4329
−10	6.788	2.98	5.98	2240	3190
−5	5.045	2.51	5.82	1665	2371
0	3.781	2.06	5.66	1248	1776
5	2.855	1.62	5.50	942.3	1342
10	2.173	1.19	5.36	717.1	1021
15	1.666	0.78	5.22	549.8	783.0
20	1.286	0.38	5.08	424.5	604.6
25	1.000	0.00	4.95	330.0	470.0
30	0.7825	0.37	4.82	258.2	367.8
35	0.6163	0.74	4.70	203.4	289.6
40	0.4883	1.09	4.59	161.1	229.5
45	0.3892	1.44	4.47	128.4	182.9
50	0.3120	1.77	4.36	103.0	146.7
55	0.2515	2.10	4.26	83.00	118.2
60	0.2038	2.43	4.15	67.26	95.80
65	0.1660	2.74	4.06	54.79	78.03
70	0.1359	3.05	3.96	44.86	63.88
75	0.1118	3.35	3.87	36.90	52.55
80	0.09240	3.64	3.78	30.49	43.43
85	0.07670	3.93	3.69	25.31	36.05
90	0.06395	4.21	3.61	21.10	30.06
95	0.05354	4.48	3.53	17.67	25.16
100	0.04501	4.75	3.45	14.85	21.15
105	0.03798	5.01	3.37	12.53	17.85
110	0.03218	5.27	3.30	10.70	15.12
115	0.02736	5.52	3.23	9.029	12.86
120	0.02335	5.77	3.16	7.704	10.97
125	0.01999	6.01	3.09	6.597	9.396

NTC THERMISTOR
naked disc range

Features

- Low price
- Proven quality
- Mechanical fixing

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

A max. = 5.2 mm

B max. = 1.9 mm

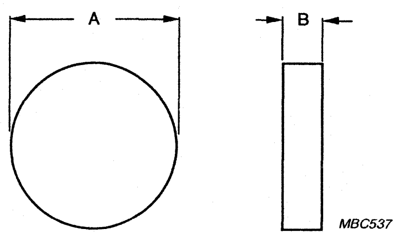


Fig.1 Component outline; see Table 1 for dimensions.

RANGE INFORMATION

Climatic category	25/125/56
Packaging	1000 pieces

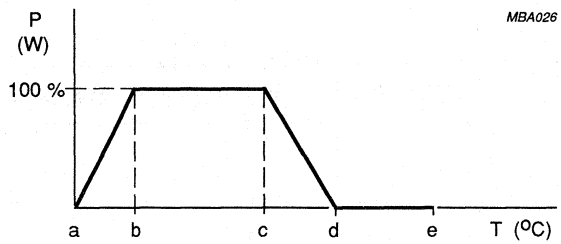


Fig.2 Derating curve; see Table 1 for curve values.

Table 1 Type information 2322 611 900 . .

Resistance at (Ω)	90027	90028	90035	90039
−20 °C				
0 °C				
20 °C				
25 °C	930 ± 10%		2577 (*)	930 (*)
40 °C		304.5 ± 8.8%		
54.5 °C			754.5 ± 5%	
60 °C				268 ± 9.5%
90 °C				
100 °C	84.5 ± 7%	39.6 ± 5%		84.5 ± 7%
110 °C			121.6 ± 3%	
120 °C		23 ± 8%		
140 °C				
$B_{25/85}$ (K)	3500 (*)	3950 (*)	4093 (*)	3500 (*)
Temperature coefficient (approx.) (%/K)	−4.05	−4.44	−4.6	−4
Derating curve max. dissipation (W)	0.25	0.25	0.5	0.25
a (°C)	−25	−30	−55	−25
b (°C)	−25	−25	−25	−25
c (°C)	55	55	55	55
d (°C)	85	85	85	85
e (°C)	125	155	125	125
Weight (approx.) (grams)	0.15	0.14	0.1	0.1
Outline A (mm)	4.7 ± 0.2	4.7 ± 0.2	5.2 − 0.3	4.4 ± 0.3
Outline B (mm)	1.4 ± 0.6	1.7 to 2.2	1.14 to 1.9	1.3 ± 0.3
Dissipation factor (approx.) (mW/K)	4.8	6.6		
Marking	orange stripe	none	yellow stripe	none

* for information only.

NTC thermistors, moulded range — 2322 641 6....

FEATURES

- Excellent for surface measurement
- Designed for harsh environments
- Based upon the 2322 640 0.... series.

APPLICATION

- Temperature control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a moulded chip with two tin-plated solid copper leads.

PACKAGING

The smallest packing quantity is 500 units.

MECHANICAL DATA

Marking

White coloured body.

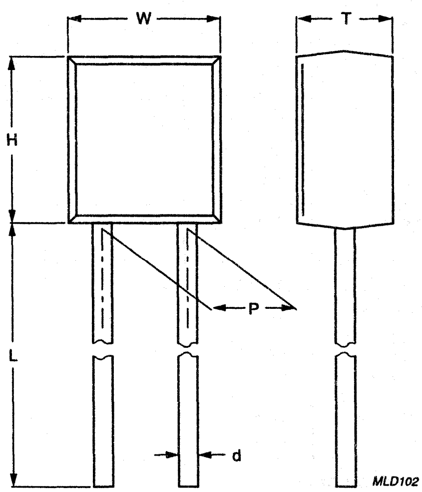
Mounting

By soldering in any position or mechanical fixing.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	2.2 to 470	kΩ
Tolerance on R_{25}-value	±3	%
$B_{25/85}$-values	3740 to 4570	K
Maximum dissipation	250	mW
Response time	≈2.7	s
Operating temperature range:		
at zero dissipation	−40 to +125	°C
at maximum dissipation	0 to 55	°C
Climatic category	40/125/56	
Mass	≈0.3	g

Outline



For dimensions see Table 1.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*.

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	see Table 1	
Standard selection tolerances	±3	%
$B_{25/85}$-values	see Table 1	
Temperature coefficient at 25 °C	see Table 1	
Climatic category	40/125/56	
Maximum dissipation	250	mW
Response time (for information only)	≈2.7	s
Minimum dielectric withstanding voltage (RMS) between leads and lead insulation	350	V
Minimum insulation resistance between leads and lead insulation at 100 V (DC)	100	MΩ
Operating temperature range:		
at zero dissipation	−40 to +125	°C
at maximum dissipation	0 to 55	°C

Derating

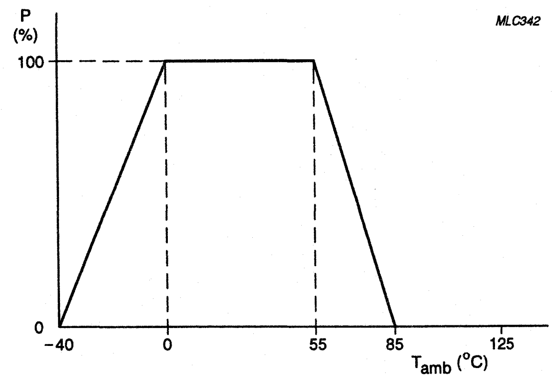


Fig.2 Power derating curve.

NTC thermistors, moulded range 2322 641 6....

Table 1 R_{25}-values, TC, mass, dimensions and catalogue numbers; see also note 1

R_{25} (kΩ)	TC (%/K)	MASS (g)	W (mm)	H (mm)	L (mm)	P (mm)	T (mm)	d (mm)	$B_{25/85}$		CATALOGUE NUMBER 2322 641 .....
									K	TOL. (%)	
2.2	4.37	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	3977	±0.75	66222
2.7	4.37	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	3977	±0.75	66272
12	4.10	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	3740	±2.0	66123
15	4.10	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	3740	±2.0	66153
100	4.57	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	4190	±1.5	66104
470	4.95	≈0.3	4 ±0.2	4.4 ±0.2	21 ±1	2.54 ±0.3	2.5 ±0.2	0.6 ±0.06	4570	±1.5	66474

Note

1. Based on the 2322 640 0.... series. Other R_{25}-values between 2.2 kΩ to 470 kΩ are available on request.

NTC thermistors, moulded range 2322 641 6....

Table 2 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (Ω) 2322 641 66222	66272
–40	33.21	2.66	6.57	73062	89667
–35	23.99	2.41	6.36	52779	64774
–30	17.52	2.17	6.15	38545	47305
–25	12.93	1.94	5.95	28444	34908
–20	9.636	1.71	5.76	21199	26017
–15	7.250	1.50	5.58	15950	19575
–10	5.505	1.29	5.40	12110	14863
–5	4.216	1.08	5.24	9275	11383
0	3.255	0.89	5.08	7162	8790
5	2.534	0.70	4.92	5575	6842
10	1.987	0.52	4.78	4372	5366
15	1.570	0.34	4.64	3454	4239
20	1.249	0.17	4.50	2747	3372
25	1.000	0.00	4.37	2200	2700
30	0.8059	0.16	4.25	1773	2176
35	0.6535	0.32	4.13	1438	1764
40	0.5330	0.47	4.02	1173	1439
45	0.4372	0.62	3.91	961.8	1180
50	0.3605	0.77	3.80	793.2	973.4
55	0.2989	0.91	3.70	657.5	807.0
60	0.2490	1.05	3.60	547.8	672.3
65	0.2084	1.18	3.51	458.6	562.8
70	0.1753	1.31	3.42	385.7	473.3
75	0.1481	1.44	3.33	325.8	399.9
80	0.1256	1.57	3.25	276.4	339.2
85	0.1070	1.69	3.16	235.5	289.0
90	0.09154	1.81	3.09	201.4	247.2
95	0.07860	1.93	3.01	172.9	212.2
100	0.06773	2.04	2.94	149.0	182.9
105	0.05858	2.15	2.87	128.9	158.2
110	0.05083	2.26	2.80	111.8	137.2
115	0.04426	2.37	2.73	97.37	119.5
120	0.03866	2.47	2.67	85.05	104.4
125	0.03387	2.57	2.61	74.52	91.46
130	0.02977	2.67	2.55	65.49	80.38
135	0.02624	2.77	2.49	57.73	70.85
140	0.02319	2.86	2.43	51.02	62.62
145	0.02055	2.96	2.38	45.22	55.49
150	0.01826	3.05	2.33	40.18	49.31

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (Ω) 2322 641 66123	66153
−40	25.78	6.81	6.09	309403	386754
−35	19.13	6.16	5.89	229509	286887
−30	14.32	5.53	5.70	171844	214805
−25	10.82	4.93	5.52	129828	162285
−20	8.245	4.35	5.35	98935	123669
−15	6.335	3.80	5.19	76020	95025
−10	4.907	3.26	5.03	58880	73600
−5	3.830	2.74	4.88	45954	57443
0	3.011	2.24	4.73	36130	45163
5	2.384	1.76	4.60	28607	35759
10	1.900	1.30	4.46	22805	28506
15	1.525	0.85	4.34	18298	22872
20	1.231	0.42	4.21	14774	18467
25	1.000	0.00	4.10	12000	15000
30	0.8171	0.41	3.98	9804	12255
35	0.6712	0.80	3.88	8054	10068
40	0.5543	1.19	3.77	6652	8315
45	0.4602	1.57	3.67	5522	6903
50	0.3839	1.94	3.57	4607	5759
55	0.3219	2.30	3.48	3862	4828
60	0.2710	2.65	3.39	3252	4066
65	0.2293	2.99	3.30	2751	3439
70	0.1947	3.33	3.22	2337	2921
75	0.1661	3.66	3.14	1993	2492
80	0.1422	3.98	3.06	1707	2134
85	0.1223	4.29	2.99	1467	1834
90	0.1055	4.60	2.92	1266	1583
95	0.09135	4.90	2.85	1096	1370
100	0.07937	5.19	2.78	952.2	1190
105	0.06919	5.48	2.71	830.2	1038
110	0.06050	5.76	2.65	726.0	907.5
115	0.05307	6.04	2.59	636.9	796.1
120	0.04670	6.31	2.53	560.4	700.5
125	0.04121	6.57	2.47	494.5	618.1

NTC thermistors, moulded range 2322 641 6....

Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (Ω) 2322 641 66104
−40	36.66	5.69	6.70	3666321
−35	26.38	5.15	6.49	2637604
−30	19.17	4.63	6.29	1916588
−25	14.06	4.13	6.10	1406120
−20	10.41	3.65	5.92	1041190
−15	7.779	3.18	5.74	777851
−10	5.861	2.73	5.57	586100
−5	4.453	2.30	5.41	445260
0	3.409	1.88	5.26	340944
5	2.631	1.48	5.11	263055
10	2.044	1.09	4.97	204447
15	1.600	0.72	4.83	160015
20	1.261	0.35	4.70	126087
25	1.000	0.00	4.57	100000
30	0.7981	0.34	4.45	79808
35	0.6408	0.67	4.35	64077
40	0.5175	1.00	4.22	51746
45	0.4202	1.32	4.11	42021
50	0.3431	1.63	4.00	34308
55	0.2816	1.93	3.90	28156
60	0.2322	2.22	3.80	23223
65	0.1925	2.51	3.71	19246
70	0.1602	2.79	3.62	16025
75	0.1340	3.06	3.53	13402
80	0.1126	3.33	3.45	11258
85	0.09496	3.59	3.36	9496
90	0.08042	3.85	3.28	8042
95	0.06837	4.10	3.21	6837
100	0.05835	4.35	3.13	5835
105	0.04998	4.59	3.06	4998
110	0.04296	4.82	2.99	4296
115	0.03705	5.05	2.92	3705
120	0.03206	5.28	2.86	3206
125	0.02783	5.50	2.80	2783

NTC thermistors, moulded range 2322 641 6....

Table 5 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (Ω) 2322 641 66474
−40	48.62	6.22	7.13	22849885
−35	34.19	5.63	6.91	16068156
−30	24.28	5.06	6.71	11412861
−25	17.42	4.51	6.52	8185271
−20	12.61	3.98	6.33	5925780
−15	9.211	3.47	6.15	4329092
−10	6.788	2.98	5.98	3190465
−5	5.045	2.51	5.82	2371302
0	3.781	2.06	5.66	1776920
5	2.855	1.62	5.50	1342065
10	2.173	1.19	5.36	1021372
15	1.666	0.78	5.22	783037
20	1.286	0.38	5.08	604583
25	1.000	0.00	4.95	470000
30	0.7825	0.37	4.82	367792
35	0.6163	0.74	4.70	289646
40	0.4883	1.09	4.59	229509
45	0.3892	1.44	4.47	182938
50	0.3120	1.77	4.36	146652
55	0.2515	2.10	4.26	118215
60	0.2038	2.43	4.15	95801
65	0.1660	2.74	4.06	78037
70	0.1359	3.05	3.96	63884
75	0.1118	3.35	3.87	52549
80	0.09240	3.64	3.78	43427
85	0.07670	3.93	3.69	30055
90	0.06395	4.21	3.61	25163
95	0.05354	4.48	3.53	21153
100	0.04501	4.75	3.45	17852
105	0.03798	5.01	3.37	15123
110	0.03218	5.27	3.30	12859
115	0.02736	5.52	3.23	10973
120	0.02335	5.77	3.16	9396
125	0.01999	6.01	3.09	9325

NTC THERMISTORS
moulded range

Features

- Designed for harsh environments
- 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 control and two solid tinned copper wires. The body colour is white.

The thermistor 2322 640 98004 is provided with a metal strip for mounting.

MECHANICAL DATA

Outlines

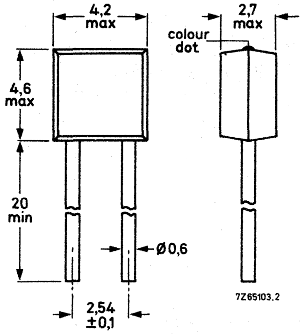


Fig.1 Type 2322 640 90004.

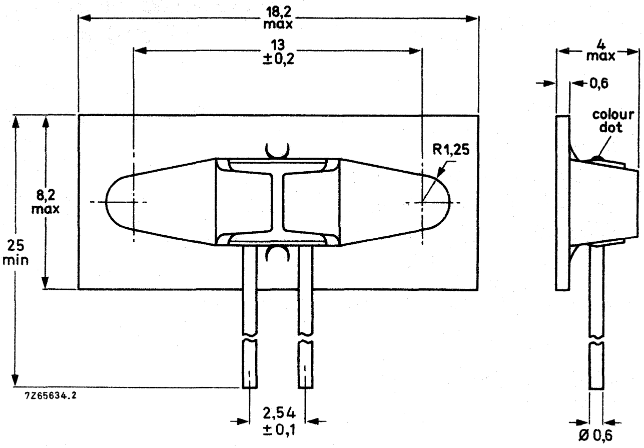


Fig.2 Type 2322 640 98004
with metal strip for mounting.

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

Impact

Free fall	1 m

Inflammability

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

PACKAGING

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

ELECTRICAL DATA

Unless otherwise specified, measured 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.

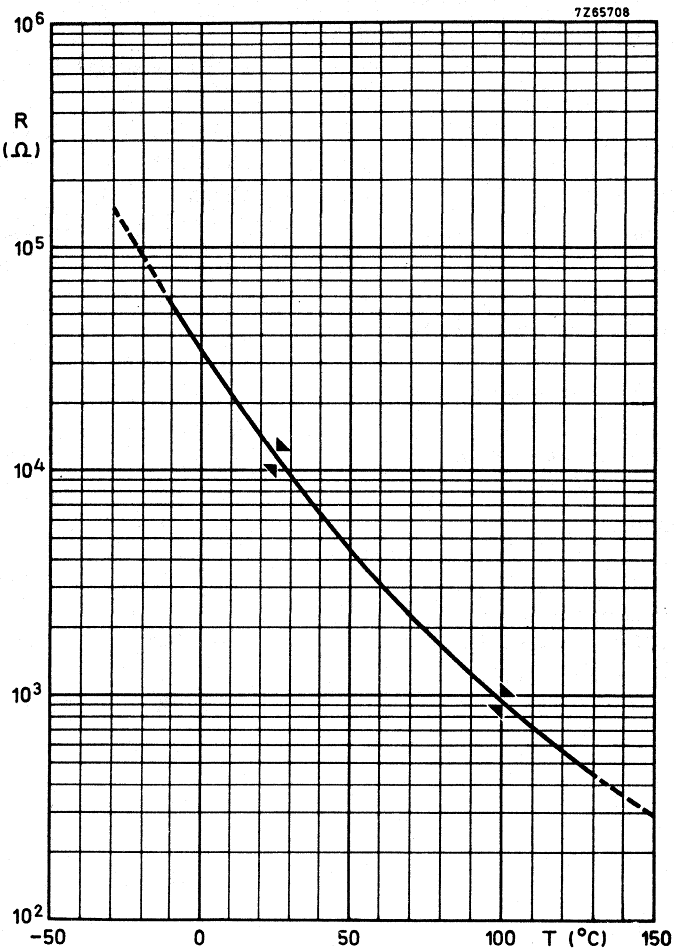


Fig.3 Typical resistance/temperature characteristics.

NTC THERMISTORS
moulded range

TEMPERATURE SENSING AND CONTROL
TEMPERATURE COMPENSATION

Features

- Designed for harsh environments
- 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

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 two solid tinned copper wires.
The body colour is white.

The thermistor 2322 640 98005 is provided with a metal strip for mounting.

MECHANICAL DATA

Outlines

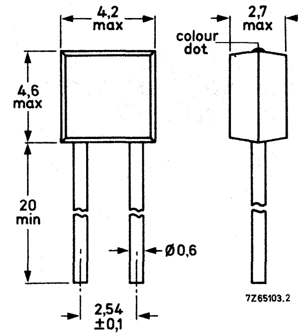


Fig.1 Type 2322 640 98005.

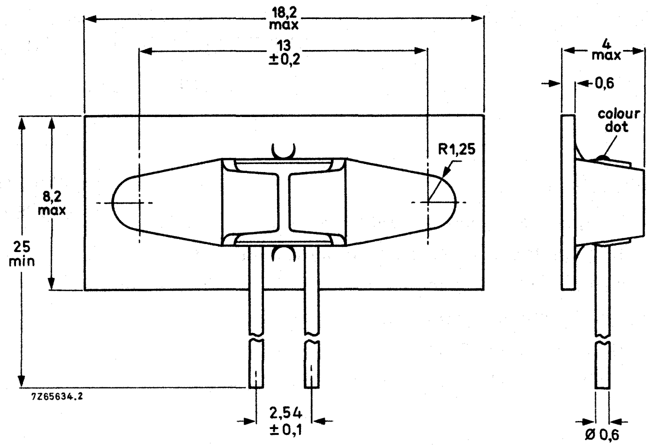


Fig.2 Type 2322 640 98005
with metal strip for mounting.

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.

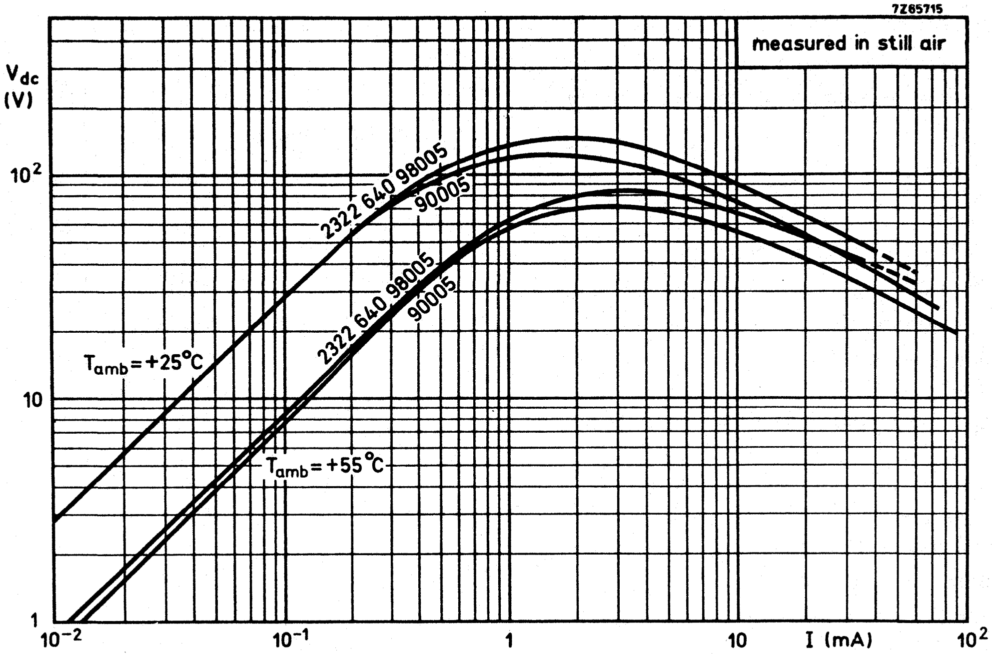


Fig.3 Typical voltage/current characteristics.

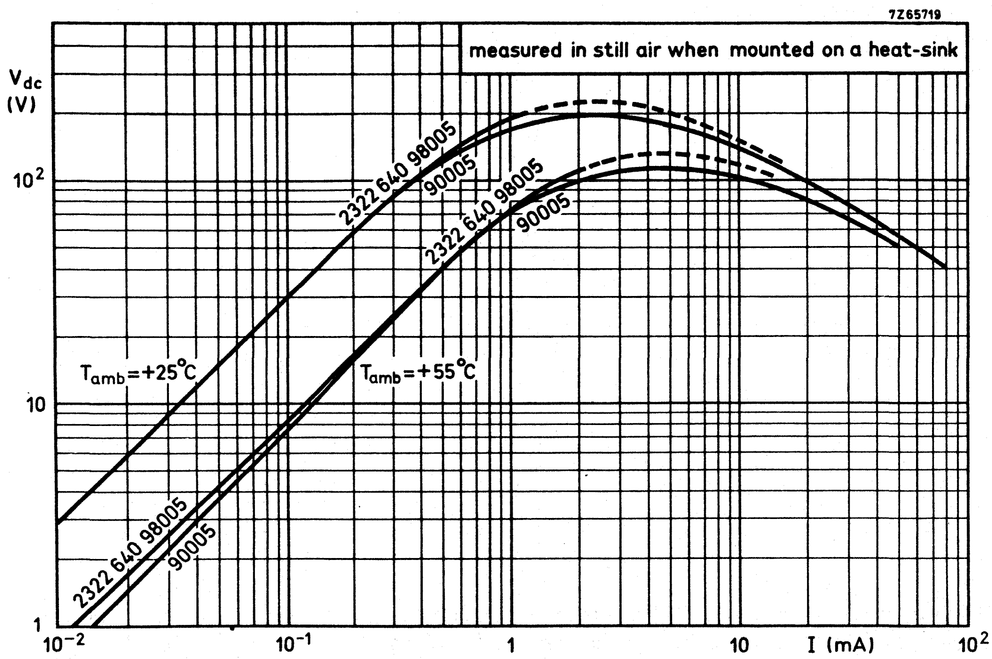


Fig.4 Typical voltage/current characteristics.

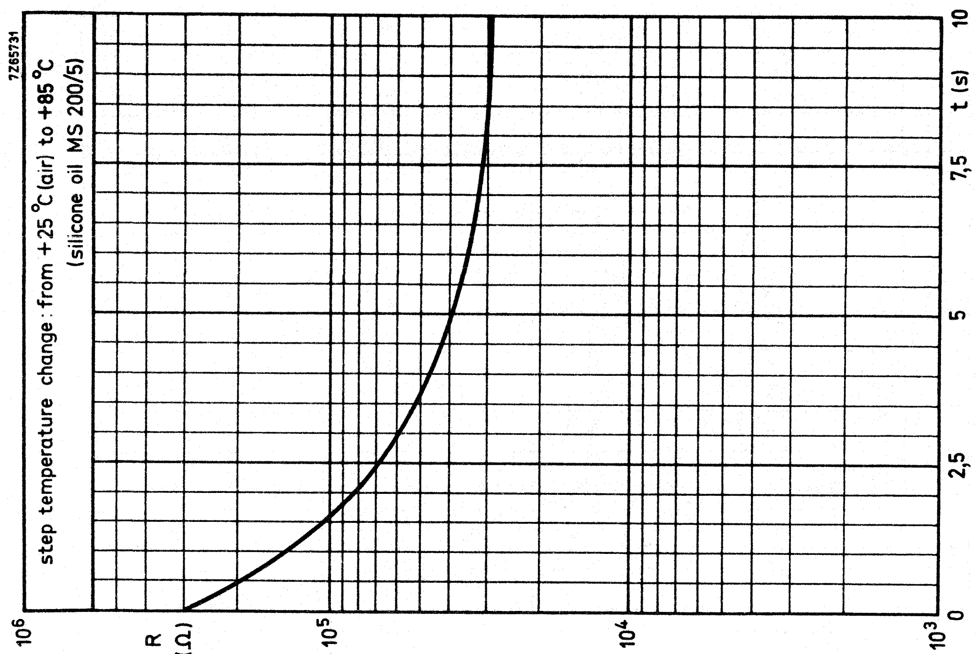


Fig.6 Typical resistance/response time characteristics.

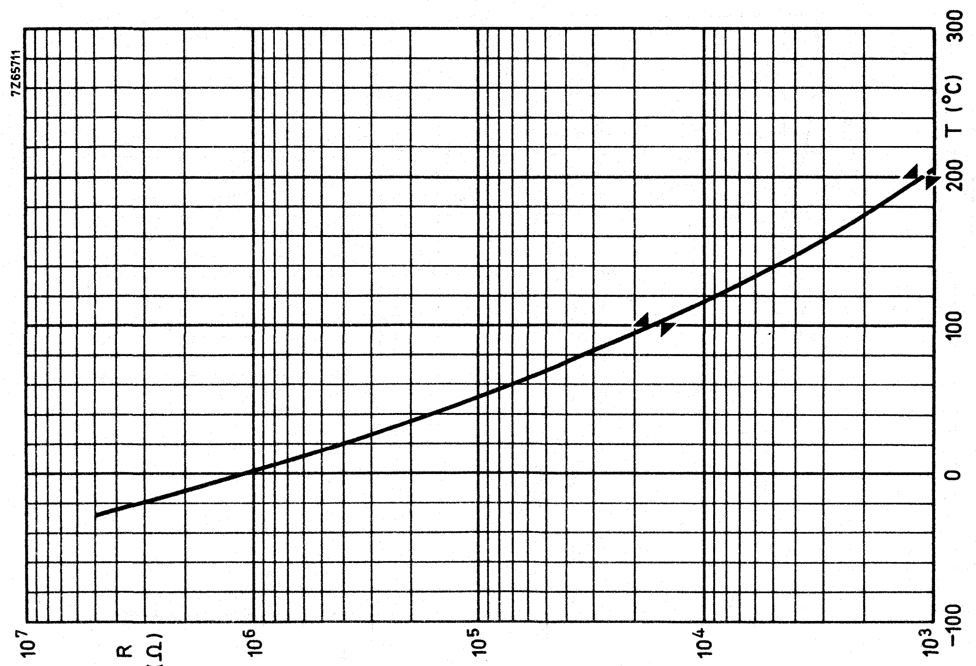


Fig.5 Typical resistance/temperature characteristics.

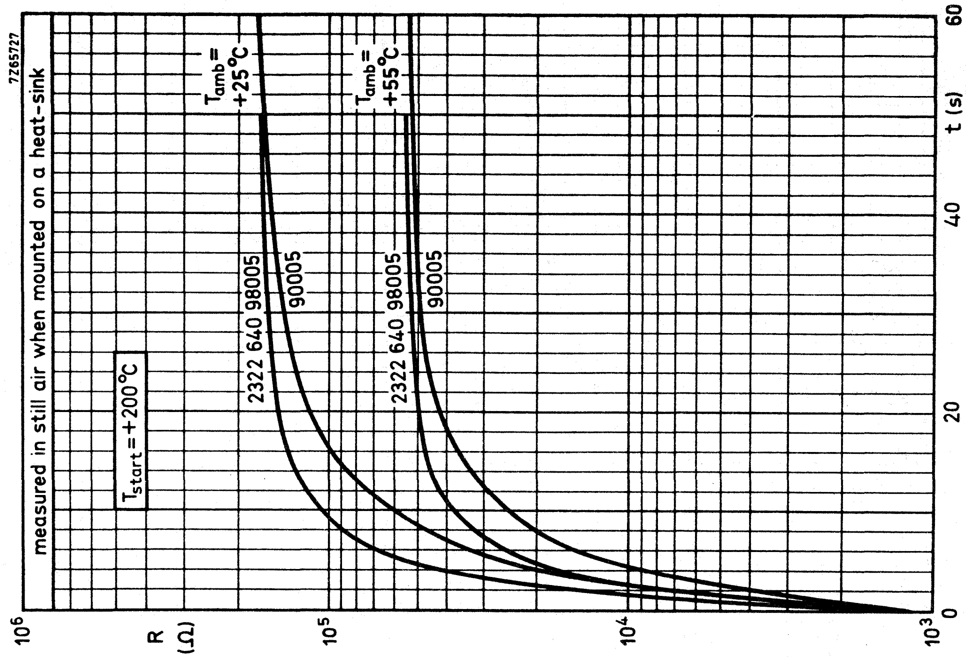


Fig.8 Typical resistance/time (cooling) characteristics.

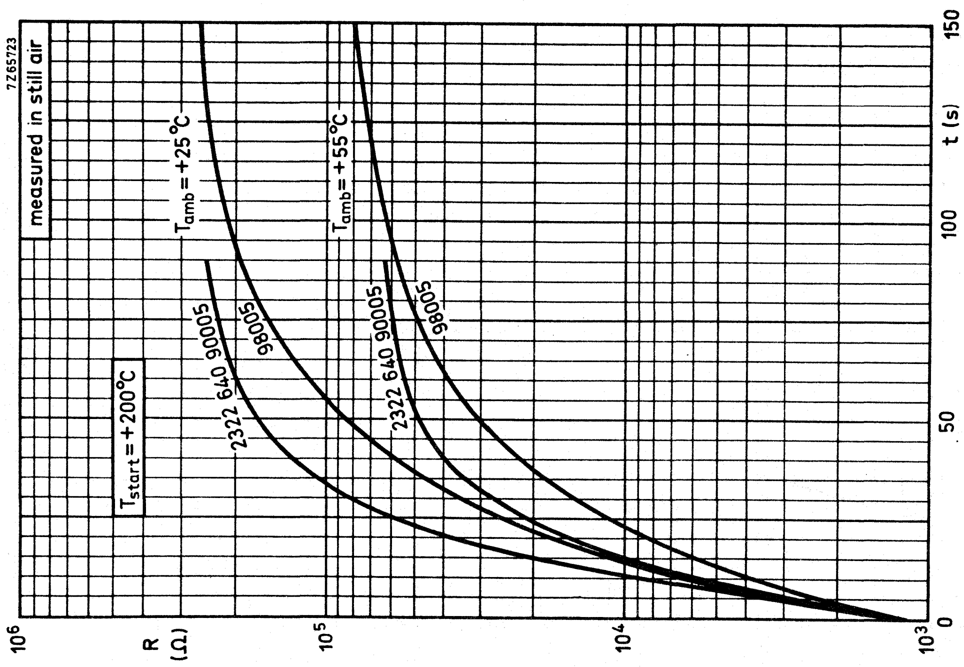


Fig.7 Typical resistance/time (cooling) characteristics.

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

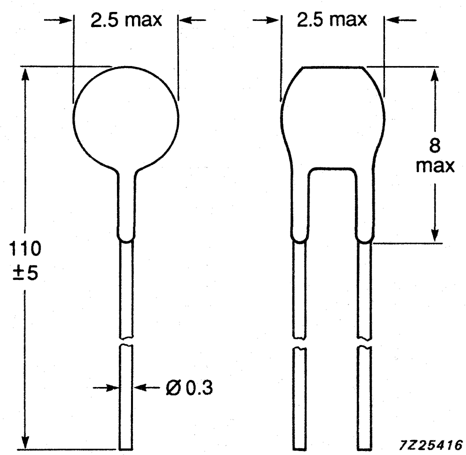


Fig.1 Component outline.

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

NTC thermistor, long and insulated leads

2322 640 90059

FEATURES

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

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two insulated nickel leads.

MOUNTING

By soldering in any position.

MARKING

The body is coated with ochre coloured epoxy lacquer and is not marked.

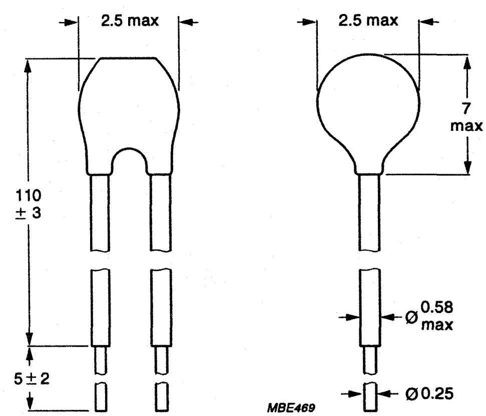
PACKAGING

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

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	9000 ±2%	Ω
25 °C	2769 ±3.82%	Ω
$B_{25/85}$-value	3977	K
Maximum dissipation	100	mW
Dissipation factor, δ	1.35	mW/K
Minimum dielectric withstanding voltage (RMS) between leads and coating	500	V
Response time	1.25	s
Operating temperature range:		
at zero power	–40 to +125	°C
at maximum power	0 to +55	°C
Climatic category	40/125/56	
Mass	≈0.16	g

MECHANICAL DATA



Dimensions in mm.

Fig.1 Component outline for 2322 640 90059 series.

NTC thermistor, long and insulated leads

2322 640 90059

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	9000 ±2%	Ω
50 °C	2769 ±3.82%	Ω
$B_{25/85}$-value	3977	K
Maximum dissipation	100	mW
Minimum dielectric withstanding voltage (RMS) between leads and coating	500	V
Response time	1.25	s
Operating temperature range:		
at zero power	−40 to +125	°C
at maximum power	0 to +55	°C
Climatic category	40/125/56	
Mass	≈0.16	g

NTC thermistor, long and insulated leads

2322 640 90059

Table 1 Resistance values at intermediate temperatures

T_{amb} (°C)	RESISTANCE (Ω)	TC (%/K)	RESISTANCE TOLERANCE (%)
−40	90923	6.57	±5.60
−35	65808	6.35	±5.09
−30	48141	6.15	±4.60
−25	35578	5.95	±4.13
−20	26550	5.76	±3.67
−15	19998	5.58	±3.23
−10	15197	5.40	±2.81
−5	11648	5.24	±2.40
0	9000	5.08	±2.00
5	7008.6	4.92	±2.38
10	5498.8	4.78	±2.76
15	4345.1	4.64	±3.12
20	3457.2	4.50	±3.47
25	2769.0	4.37	±3.82
30	2231.7	4.25	±4.16
35	1809.6	4.13	±4.48
40	1476.0	4.02	±4.80
45	1210.6	3.91	±5.12
50	998.37	3.80	±5.42
55	827.59	3.70	±5.72
60	689.46	3.60	±6.01
65	577.15	3.51	±6.29
70	485.38	3.42	±6.57
75	410.02	3.33	±6.84
80	347.86	3.25	±7.10
85	296.35	3.16	±7.36
90	253.47	3.09	±7.61
95	217.64	3.01	±7.86
100	187.57	2.94	±8.10
105	162.24	2.87	±8.33
110	140.81	2.80	±8.56
115	122.63	2.73	±8.79
120	107.14	2.67	±9.01
125	93.90	2.61	±9.22

NTC thermistors, long lead sensors — 2322 645 10/20... series

FEATURES

- Accuracy of 0.5 °C between 0 °C and 50 °C
- Small diameter
- High stability over a long life
- Long and flexible leads for special mounting or assembly requirements.

APPLICATIONS

- Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a chip with two insulated or non-insulated nickel leads.

MOUNTING

By soldering in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	see Table 2	
50 °C	see Table 2	
$B_{25/85}$-value	3977	K
ΔT ensured between 0 °C and 50 °C	±0.5	°C
Temperature coefficient	see Table 2	
Maximum dissipation	100	mW
Minimum dielectric withstanding voltage (RMS) between leads and coating	500	V
Operating temperature range	−40 to +125	°C
Climatic category	40/125/56	
Mass	≈0.2	g

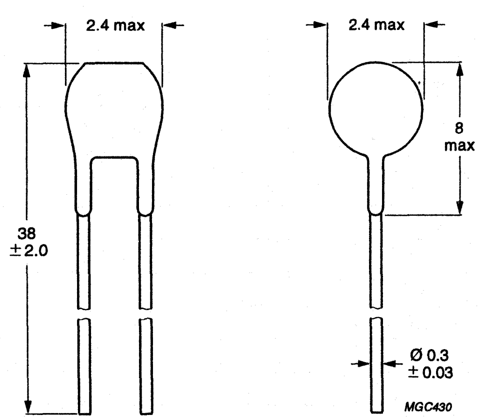
PACKAGING

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

MARKING

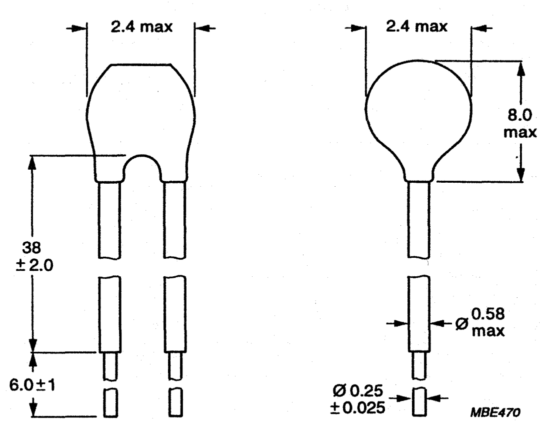
The body is coloured with ochre lacquer and not marked.

MECHANICAL DATA



Dimensions in mm.

Fig.1 Component outline for 2322 645 10... series.



Dimensions in mm.

Fig.2 Component outline for 2322 645 20... series.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	see Table 2	
50 °C	see Table 2	
$B_{25/85}$-value	3977	K
ΔT ensured between 0 °C and 50 °C	±0.5	°C
Temperature coefficient	see Table 2	
Maximum dissipation	100	mW
Minimum dielectric withstanding voltage (RMS) between leads and coating	500	V
Operating temperature range	–40 to +125	°C
Climatic category	40/125/56	
Mass	≈0.2	g

Table 1 $B_{25/85}$-value and catalogue numbers

$B_{25/85}$-VALUE (K)	R_{25} (kΩ)	CATALOGUE NUMBER 2322 645 .....(1)
3977	3	.0302
3977	5	.0502
3977	10	.0103

Note

1. Replace dot in last 5 digits of catalogue number by 1 for non-insulated or 2 for insulated leads.

Derating

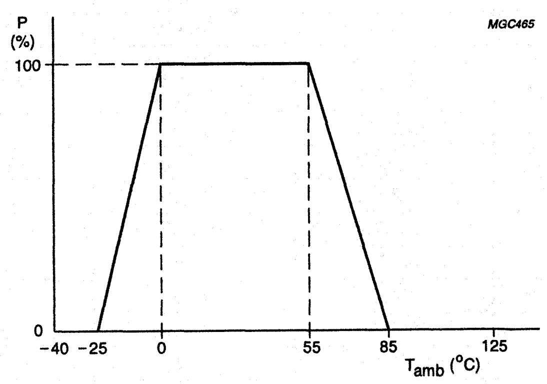


Fig.3 Power derating curve.

Table 2 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ)		
				2322 645 .....(1)		
				.0302	.0502	.0103
–40	33.21	0.68	6.57	99.63	166.1	332.1
–35	23.99	0.66	6.36	71.97	120.0	239.9
–30	17.52	0.64	6.15	52.56	87.60	175.2
–25	12.93	0.62	5.95	38.79	64.65	129.3
–20	9.636	0.59	5.76	28.91	48.18	96.36
–15	7.250	0.57	5.58	21.75	36.25	72.50
–10	5.505	0.55	5.40	16.51	27.52	55.05
–5	4.216	0.52	5.24	12.65	21.08	42.16
0	3.255	0.50	5.08	9.766	16.28	32.56
5	2.534	0.50	4.92	7.602	12.67	25.34
10	1.987	0.50	4.78	5.962	9.936	19.87
15	1.570	0.50	4.64	4.710	7.849	15.70
20	1.249	0.50	4.50	3.746	6.244	12.49
25	1.000	0.50	4.37	3.000	5.000	10.00
30	0.8059	0.50	4.25	2.418	4.030	8.059
35	0.6535	0.50	4.13	1.960	3.267	6.535
40	0.5330	0.50	4.02	1.599	2.665	5.330
45	0.4372	0.50	3.91	1.312	2.186	4.372
50	0.3605	0.50	3.80	1.082	1.803	3.606
55	0.2989	0.55	3.70	0.8966	1.494	2.989
60	0.2490	0.61	3.60	0.7470	1.245	2.490
65	0.2084	0.66	3.51	0.6253	1.042	2.084
70	0.1753	0.72	3.42	0.5259	0.8765	1.753
75	0.1481	0.77	3.33	0.4443	0.7405	1.481
80	0.1256	0.83	3.25	0.3769	0.6282	1.256
85	0.1070	0.89	3.16	0.3211	0.5352	1.070
90	0.09154	0.95	3.09	0.2746	0.4577	0.9154
95	0.07860	1.02	3.01	0.2358	0.3930	0.7860
100	0.06773	1.08	2.94	0.2032	0.3387	0.6773
105	0.05858	1.14	2.87	0.1757	0.2929	0.5858
110	0.05083	1.21	2.80	0.1525	0.2542	0.5083
115	0.04426	1.27	2.73	0.1328	0.2213	0.4426
120	0.03866	1.34	2.67	0.1160	0.1933	0.3866
125	0.03387	1.41	2.61	0.1016	0.1694	0.3387

Note

1. Replace dot in last 5 digits of catalogue number by 1 for non-insulated or 2 for insulated leads.

NTC thermistors, special long lead sensors

2322 641 2/3/4....

FEATURES

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

APPLICATION

Temperature sensing and control.

DESCRIPTION

These thermistors have a negative temperature coefficient. The epoxy-coated type (2322 641 2....) consists of a chip with UL wire and is lacquered and insulated with black epoxy.

The water-resistant type (2322 641 3....) and the brass-pipe type (2322 641 4....) are suitable for application in various environmental conditions.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	2.2 to 100	kΩ
Tolerance on R_{25}-value	±3	%
Tolerance on $B_{25/85}$-value	±1.5 or ±0.75	%
Maximum dissipation	250	mW
Operating temperature range:		
at zero dissipation (continuously)	−40 to +85	°C
at maximum dissipation	0 to +50	°C
Climatic category	40/085/56	
Total length (L); note 1 and Figs 1 to 2	400 ±10	mm
Lead wire; note 1	UL-2468.AWG24 wire	
Mass:		
2322 641 2....	≈4	g
2322 641 3....	≈6	g
2322 641 4....	≈6	g

Note

1. Wire length and wire type are optional on request. The products can be provided with a connector on request.

ORDERING INFORMATION

Table 1 R_{25}-values and catalogue numbers; note 1

R_{25} (kΩ)	$B_{25/85}$-VALUE	CATALOGUE NUMBER 2322 641 .....(2)		
		EPOXY-COATED TYPE	WATER-RESISTANT TYPE	BRASS-PIPE TYPE
2.2	3977 K ±0.75%	26222	36222	46222
5	3977 K ±0.75%	26502	36502	–
10	3977 K ±0.75%	26103	36103	46103
47	4090 K ±1.5%	26473	36473	–
100	4190 K ±1.5%	26104	36104	46104

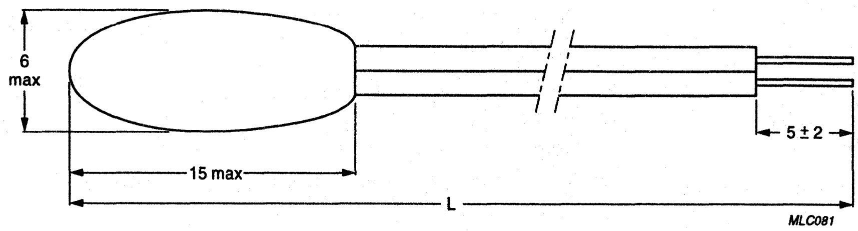
Notes

1. Other values based on the 2322 640 0.... series are available on request.
2. The specified catalogue numbers refer to products with L = 400 mm, without connector and adopt UL-2468.AWG24 wire.

MARKING

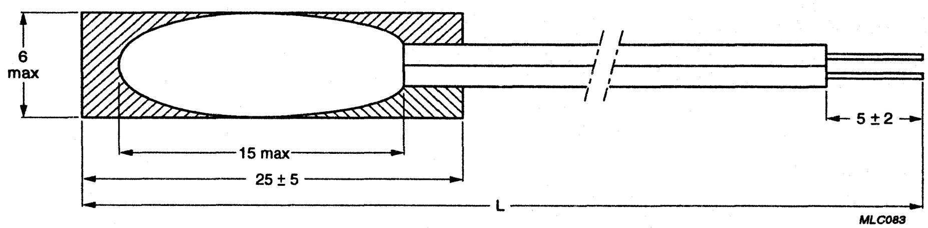
UL mark on wire, no mark on body.

MECHANICAL DATA



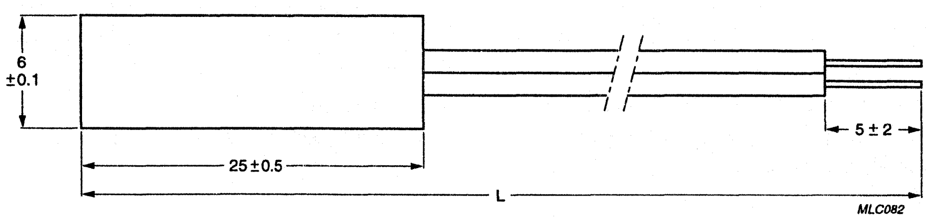
Dimensions in mm.
L = 400 ±10 mm. Other wire lengths available on request.

Fig.1 Epoxy-coated type 2322 641 2....



Dimensions in mm.
L = 400 ±10 mm. Other wire lengths available on request.

Fig.2 Water-resistant type 2322 641 3....



Dimensions in mm.
L = 400 ±10 mm. Other wire lengths available on request.

Fig.3 Brass-pipe type 2322 641 4....

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUE	UNIT
Resistance value at 25 °C (R_{25})	2.2 to 470	kΩ
Tolerance on R_{25}-value	±3	%
Tolerance on $B_{25/85}$-value	±1.5 or ±0.75	%
Maximum dissipation	250	mW
Dissipation factor:		
2322 641 2....	6.0	mW/K
2322 641 3....	8.0	mW/K
2322 641 4....	6.0	mW/K
Response time; note 1:		
2322 641 2....	≈7	s
2322 641 3....	≈15	s
2322 641 4....	≈10	s

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 from 25 °C in air to 85 °C in oil.

Derating

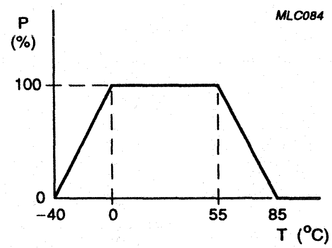


Fig.4 Derating curve.

NTC thermistors, special long lead sensors

2322 641 2/3/4....

R-T characteristics

Table 2 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 641 2/3/4 .....; see Table 4, note 1		
				.6222	.6502	.6103
−40	33.21	2.66	6.57	73.06	166.1	332.1
−35	23.99	2.41	6.36	52.78	120.0	240.0
−30	17.52	2.17	6.15	38.55	87.60	175.2
−25	12.93	1.94	5.95	28.44	64.65	129.3
−20	9.636	1.71	5.76	21.20	48.18	96.36
−15	7.250	1.50	5.58	15.95	36.25	72.50
−10	5.505	1.29	5.40	12.11	27.52	55.05
−5	4.216	1.08	5.24	9.275	21.08	42.16
0	3.255	0.89	5.08	7.162	16.28	32.56
5	2.534	0.70	4.92	5.575	12.67	25.34
10	1.987	0.52	4.78	4.372	9.936	19.87
15	1.570	0.34	4.64	3.454	7.849	15.70
20	1.249	0.17	4.50	2.747	6.244	12.49
25	1.000	0.00	4.37	2.200	5.000	10.00
30	0.8059	0.16	4.25	1.773	4.030	8.059
35	0.6535	0.32	4.13	1.438	3.267	6.535
40	0.5330	0.47	4.02	1.173	2.665	5.330
45	0.4372	0.62	3.91	0.9618	2.186	4.372
50	0.3605	0.77	3.80	0.7932	1.803	3.606
55	0.2989	0.91	3.70	0.6575	1.494	2.989
60	0.2490	1.05	3.60	0.5478	1.245	2.490
65	0.2084	1.18	3.51	0.4586	1.042	2.084
70	0.1753	1.31	3.42	0.3857	0.8765	1.753
75	0.1481	1.44	3.33	0.3258	0.7405	1.481
80	0.1256	1.57	3.25	0.2764	0.6282	1.256
85	0.1070	1.69	3.16	0.2355	0.5352	1.070

NTC thermistors, special long lead sensors

2322 641 2/3/4....

Table 3 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 641 2/3/4 ....; see Table 4, note 1 .6473
–40	33.81	5.55	6.55	1589
–35	24.50	5.02	6.34	1151
–30	17.93	4.52	6.15	842.8
–25	13.25	4.03	5.96	622.6
–20	9.875	3.56	5.78	464.1
–15	7.425	3.10	5.61	349.0
–10	5.630	2.67	5.45	264.6
–5	4.304	2.24	5.29	202.3
0	3.315	1.84	5.14	155.8
5	2.573	1.44	4.99	120.9
10	2.011	1.07	4.85	94.53
15	1.583	0.70	4.72	74.40
20	1.254	0.34	4.59	58.95
25	1.000	0.00	4.46	47.00
30	0.8024	0.33	4.34	37.71
35	0.6474	0.66	4.23	30.43
40	0.5255	0.98	4.12	24.70
45	0.4288	1.28	4.01	20.15
50	0.3518	1.59	3.91	16.53
55	0.2901	1.88	3.81	13.63
60	0.2403	2.17	3.71	11.30
65	0.2001	2.45	3.62	9.404
70	0.1674	2.72	3.53	7.865
75	0.1406	2.99	3.44	6.607
80	0.1186	3.25	3.36	5.573
85	0.1004	3.51	3.28	4.721

Table 4 Resistance values at intermediate temperatures

T_{amb} (°C)	R_T/R_{25}	ΔR DUE TO B-TOLERANCE (%)	TC (%/K)	R_{25} (kΩ) 2322 641 2/3/4 ....; see note 1 .6104
−40	36.66	5.69	6.70	3666
−35	26.38	5.15	6.49	2638
−30	19.17	4.63	6.29	1917
−25	14.06	4.13	6.10	1406
−20	10.41	3.65	5.92	1041
−15	7.779	3.18	5.74	777.9
−10	5.861	2.73	5.57	586.1
−5	4.453	2.30	5.41	445.3
0	3.409	1.88	5.26	340.9
5	2.631	1.48	5.11	263.1
10	2.044	1.09	4.97	204.4
15	1.600	0.72	4.83	160.0
20	1.261	0.35	4.70	126.1
25	1.000	0.00	4.57	100.0
30	0.7981	0.34	4.45	79.81
35	0.6408	0.67	4.35	64.08
40	0.5175	1.00	4.22	51.74
45	0.4202	1.32	4.11	42.02
50	0.3431	1.63	4.00	34.31
55	0.2816	1.93	3.90	28.16
60	0.2322	2.22	3.80	23.22
65	0.1925	2.51	3.71	19.25
70	0.1602	2.79	3.62	16.03
75	0.1340	3.06	3.53	13.40
80	0.1126	3.33	3.45	11.26
85	0.09496	3.59	3.36	9.496

Note to Tables 2, 3 and 4

1. Replace dot in last 5 digits of catalogue number by a number according to the following details: 2 for epoxy-coated type; 3 for water-resistant type and 4 for brass-pipe type.

TESTS AND REQUIREMENTS

Table 5 Stability tests

IEC	CECC	TEST	PROCEDURE	DRIFT REQUIREMENT
	D3; 4.20.1	endurance	85 °C; 1000 hours	ΔR/R < 5%
68-2-1		endurance	−40 °C; 1000 hours	ΔR/R < 5%
539		endurance	250 mW; 55 °C; 1000 hours	ΔR/R < 5%
68-2-3	D1; 4.19	damp heat, steady state	56 days at 40 °C; 90 to 95% RH	ΔR/R < 7%
68-2-14	C2; 4.14	rapid change of temperature	−40 to +85 °C; 50 cycles	ΔR/R < 5%

NTC THERMISTORS

screw range

Features

- Easy mounting
- Rugged construction

TEMPERATURE SENSING AND CONTROL

QUICK REFERENCE DATA

	640 7....	642 7....
Resistance value at +25 °C	2.2 kΩ to 470 kΩ	3.3 Ω to 1.5 kΩ
Dissipation factor approx. (see note 1)	23 mW/K	25 mW/K
Thermal time constant approx. (see note 1)	7.5 s	20 s
Operating temperature range		
at zero power	−25 to +100 °C	−25 to +100 °C
at maximum power	0 to +55 °C	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

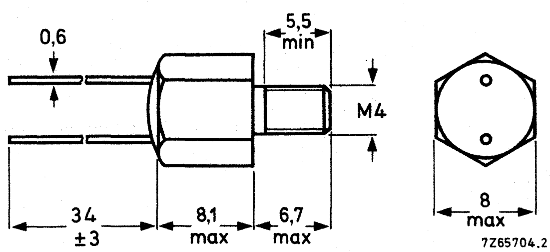


Fig.1 Component outline.

Note

1. Measured with screw mounted on an aluminium heatsink of 100 cm², thickness 1.5 mm, in still air, T_{amb} = +25 °C.

Marking

The last 4 digits of the catalogue number are printed on the stud in accordance with the information in Tables 1 and 2.

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
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 Tables 1 and 2.

For typical resistance/temperature and voltage/current characteristics, refer to data for type 2322 640 6.... or 2322 642 6....

Table 1 Catalogue number 2322 640 7....

SUFFIX OF CATALOGUE NUMBER	R_{25} (Ω)	$B_{25/85}$-VALUE		TEMPERATURE COEFFICIENT AT 25 °C (%/K)
R_{25} ±5%		K	±%	
3472	4700	3977	0.75	−4.37
3103	10000	3977	0.75	−4.37
3123	12000	3740	1.5	−4.10
3153	15000	3740	1.5	−4.10
3473	47000	4090	1.5	−4.46
3104	100000	4190	1.5	−4.57
3154	150000	4370	2.5	−4.75
3474	470000	4570	2	−4.95

Table 2 Catalogue number 2322 642 7....

SUFFIX OF CATALOGUE NUMBER		R_{25} (Ω)	$B_{25/85}$-VALUE		TEMPERATURE COEFFICIENT AT 25 °C (%/K)
TOL. 5%	TOL. 10%		K	±%	
3478	2478	4.7	2750	5	−3.1
3109	2109	10	2875	5	−3.2
3479	2479	47	3150	5	−3.5
3101	2101	100	3300	5	−3.7
3151	2151	150	3375	5	−3.8
3471	2471	470	3650	5	−4.1
3102	2102	1000	3825	5	−4.3
3152	2152	1500	3975	5	−4.5

NTC thermistors, steel cap | 2322 640 90042

FEATURES

- Excellent performance in humid environments
- High mechanical strength
- AMP connectors for easy connection
- Excellent accuracy over a wide temperature range.

APPLICATIONS

- Sensors for water temperature control in, for example:
  - washing machines
  - dish washers
  - heat pumps
  - electric boilers.

DESCRIPTION

These thermistors have a negative temperature coefficient. The device consists of a ceramic material which is mounted in a capsule of stainless steel and provided with two 6.3 mm tinned bronze spade connectors.

The device is non-flammable and the housing is stainless steel in accordance with *"DIN 1.4301"* (× 5 CrNi 18 9).

PACKAGING

The thermistors are packed in cardboard boxes; the smallest packing quantity is 50 units.

MARKING

Green marking between the connectors.

MOUNTING

Electrical mounting with AMP connectors in any position.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	35875 ±7%	Ω
25 °C	12000 ±4%	Ω
85 °C	1475 ±3%	Ω
100 °C	963 ±4.2%	Ω
Maximum dissipation	250	mW
Operating temperature range at zero power:		
continuous	−25 to +110	°C
peak	130	°C
Operating temperature range at maximum power	0 to +55	°C
Mass	≈8	g

QUALITY LEVEL

Sampling and data evaluation for quality level in accordance with *"IEC publication 410"*, AQL:

Inoperatives: 25%

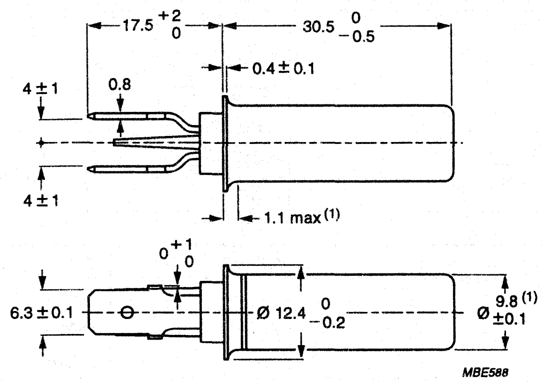
Electrical for IEC 410, sections 4.1, 4.2, 4.8 and 4.11: 1%

Mechanical for all dimensions: 1.5%

Mechanical for IEC 410, section 3.4.1: 0.25%.s

NTC thermistors, steel cap 2322 640 90042

MECHANICAL DATA



Dimensions in mm.

(1) To be controlled by gauging.

Fig.1 Component outline.

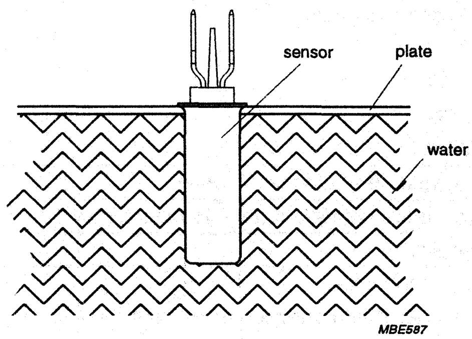


Fig.2 Method of application.

ELECTRICAL DATA

Derating

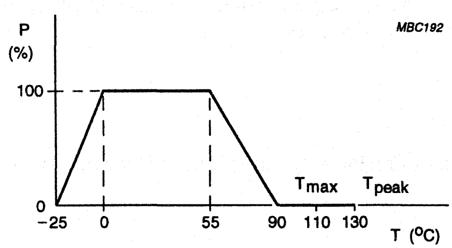


Fig.3 Power derating curve.

Electrical characteristics

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"* and *"CECC 43000"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Resistance value at:		
0 °C	35875 ±7%	Ω
25 °C	12000 ±4%	Ω
85 °C	1475 ±3%	Ω
100 °C	963 ±4.2%	Ω
$B_{25/85}$-value (for information only)	3730	K
Temperature coefficient (for information only)	−4.2	%/K
Dissipation	≤250	mW
Dissipation factor:		
in still air (for information only); note 1	7.5	mW/K
in still water (for information only); note 1	18	mW/K
Thermal time constant (τ) in still air (for information only); note 1	285	s
Response time; note 2	13 to 16	s
Temperature gradient; note 3	≤0.02	K/K
Operating temperature range at:		
zero power; continuously	−25 to +110	°C
zero power; peak during 24 hours	130	°C
maximum power	0 to +55	°C
Minimum dielectric withstanding voltage (RMS) between terminals and capsule during:		
1 minute	1500	V
10 seconds	1650	V
Minimum insulation resistance between terminals and capsule at 100 V (DC)	100	MΩ

Notes

1. Measured with AMP connectors in still air with solid copper wires of 1 mm diameter.
2. The response time is the time necessary to change 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:
   a) initial temperature: air at 25 °C
   b) final temperature: water at 100 °C.
3. The temperature gradient is the difference per degree Celsius between the real temperature of the liquid (water) and the temperature measured by the sensor.

NTC Thermistors

Introduction to NTC temperature compensation

FEATURES

- Low-cost solution to stability problems in electronic circuitry
- Wide range of resistance values makes selection easy
- 5 and 10% tolerances on R_{25} available
- Maximum power dissipation 0.5 W
- Temperature range –25 to +125 °C.

MECHANICAL OPTIONS

- Taped on reel, 1e pitch (2322 642 4 ....) and 2e pitch (2322 642 3....).

APPLICATIONS

- Consumer applications
- Industrial electronics
- Electronic data processing.

DESCRIPTION

The output current of an electronic circuit such as the amplifier shown in Fig.1 can be compensated for the effect of temperature by connecting an NTC thermistor in the input bias circuit.

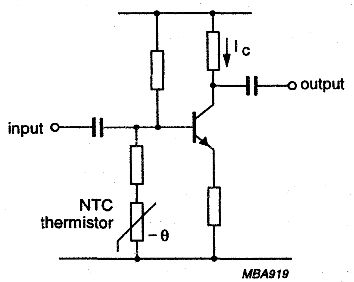


Fig.1 Temperature compensation of an amplifier circuit.

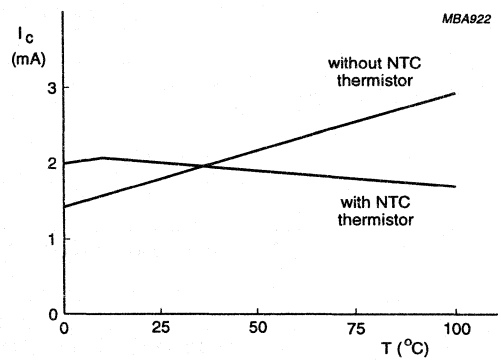


Fig.2 Typical current/temperature compensation characteristic.

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

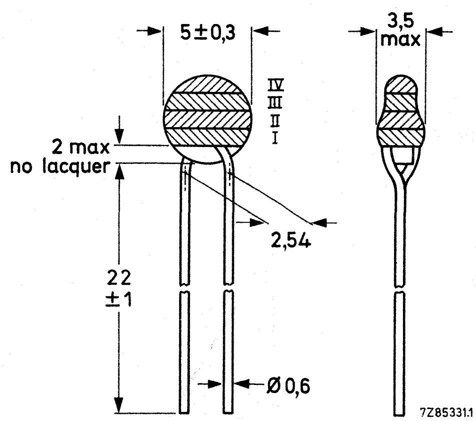


Fig.1 Component outline.

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

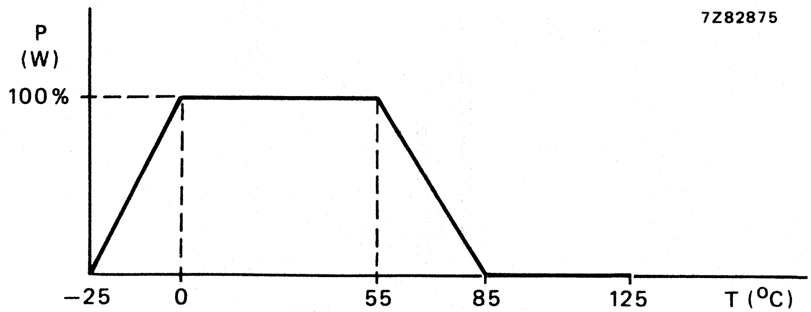


Fig. 2 Derating curve.

* 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.

POSITIVE TEMPERATURE COEFFICIENT (PTC) THERMISTORS

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 thermistor 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 Chapter "Applications".

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+}
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:

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

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 in the formula:

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

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 polarization 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 thermistor with respect to its switching temperature, causing the potential barriers to decrease in strength. This means that the PTC thermistor 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 thermistor are, therefore, restricted by a certain temperature limit.

Since the PTC thermistor 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 Chapter "Electrical properties" are thus restricted to this frequency range.

ELECTRICAL PROPERTIES

Resistance/temperature characteristics

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

Current/voltage characteristics

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

As can be seen in 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.

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

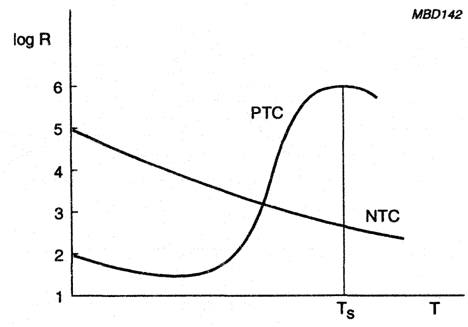


Fig.1 Typical resistance/temperature characteristic curves for PTC and NTC thermistors.

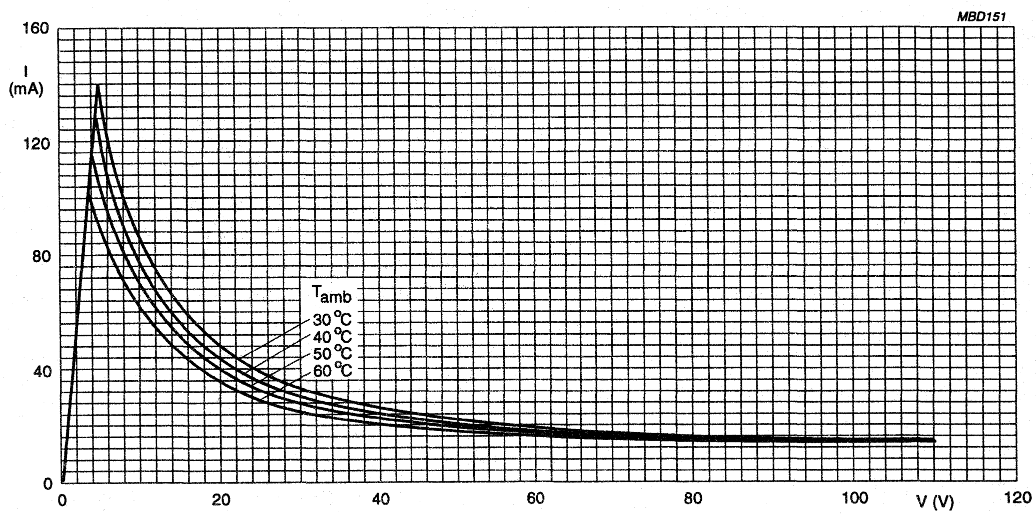


Fig.2 Current/voltage characteristics of a PTC thermistor plotted on a linear scale and using ambient temperature as the parameter.

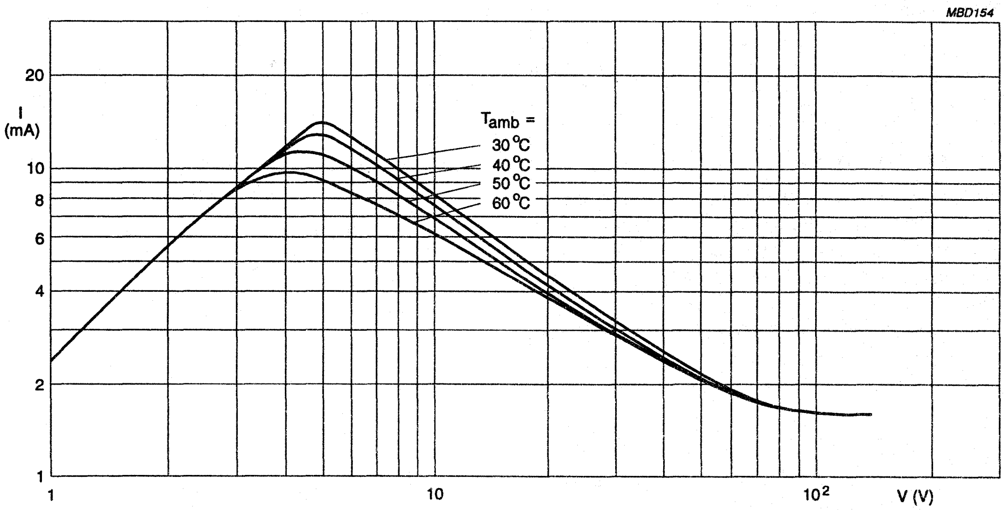


Fig.3 Current/voltage characteristics of a PTC thermistor plotted on a logarithmic scale, using ambient temperature as the parameter.

The dissipation factor (measured in mW/K) 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 I/V 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:

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

Remark: This equation is only valid for temperatures lower 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:

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

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

where R is the PTC thermistor resistance at T_s.

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}.

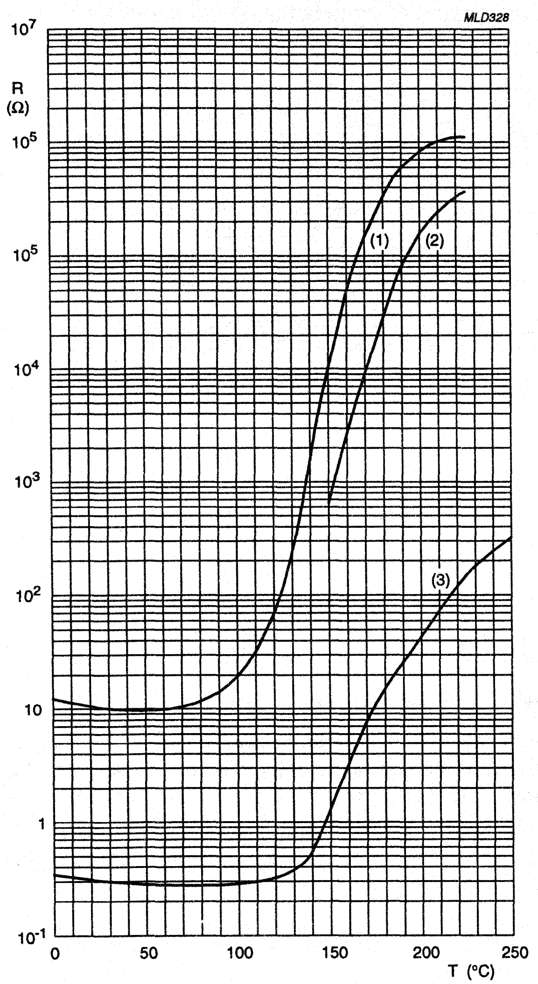
The non-trip current (I_{nt}) is defined as the guaranteed maximum current at which the thermistor will not switch, and is given by:

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

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

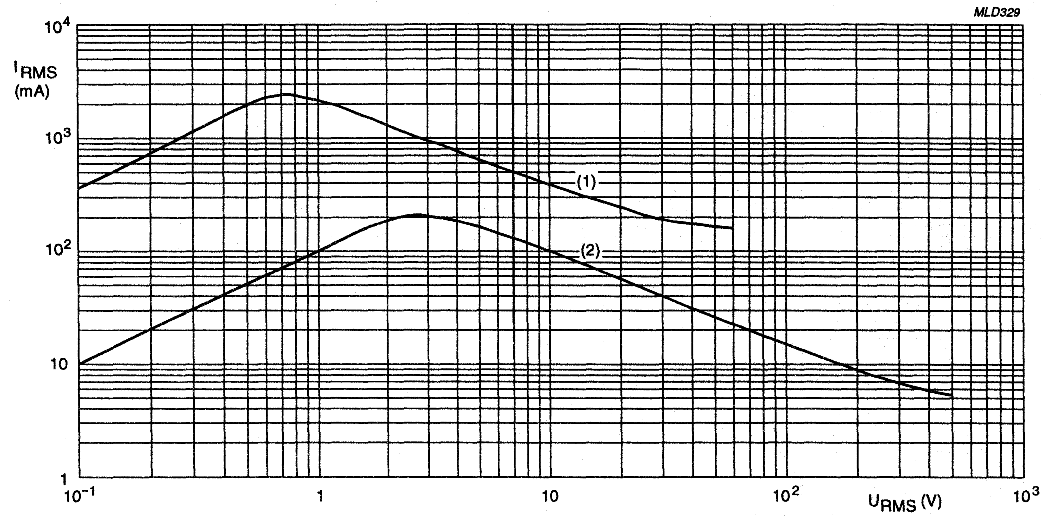
A security margin of $-\omega$ °C is maintained to ensure that the thermistor will not switch.

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



Curve 1: For 2322 662 93074 (≤5 V (DC)).
Curve 2: For 2322 662 93074; 345 V_{pulse}.
Curve 3: For 2322 664 52021 (≤5 V (DC)).

Fig.4 R/T characteristics of thermistor types 2322 662 93074 and 2322 664 52051.



Curve 1: For 2322 662 93074.
Curve 2: For 2322 664 52021.

Fig.5 Typical I/V characteristics of thermistor types 2322 662 93074 and 2322 664 52051, measured in still air at 25 °C.

PTC thermistors in series with a load

It can be shown from the I/V characteristics that, because of the non-linearity of the PTC thermistors curve, three working points are possible when a load R_L is connected in series with a PTC thermistor (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 I/V 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.

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 I/V 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.

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

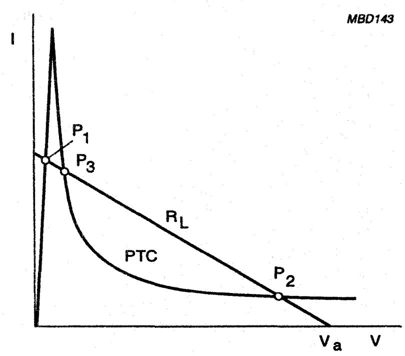


Fig.6 PTC thermistor in series with a load showing the possible working points.

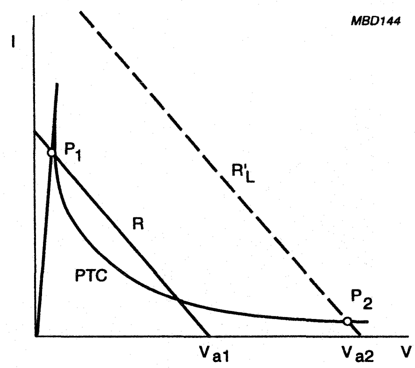


Fig.7 PTC thermistor in series with a load showing the influence of the supply voltage V_a.

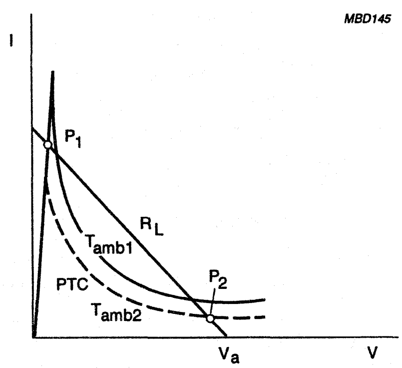


Fig.8 PTC thermistor in series with a load showing the influence of the ambient temperature.

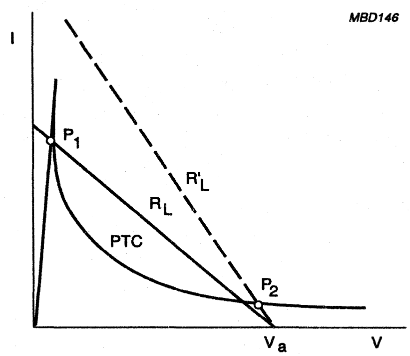


Fig.9 PTC thermistor in series with a load showing the influence of the load resistance.

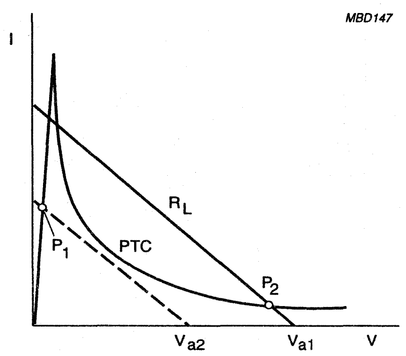


Fig.10 PTC thermistor in series with a load showing the influence of a decrease in supply voltage V_a.

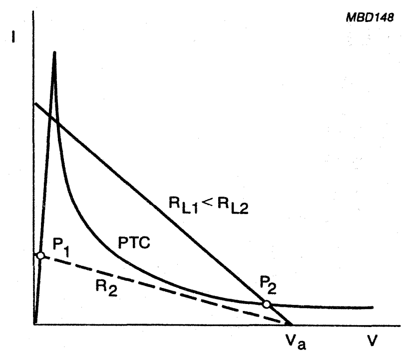


Fig.11 PTC thermistor in series with a load showing the influence of an increase in load resistance.

Current/time characteristic

If a PTC thermistor is connected in series with a resistance of such a value that the peak of the I/V curve lies under the load line, the PTC thermistor 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_L (see Fig.13) and the ambient temperature.

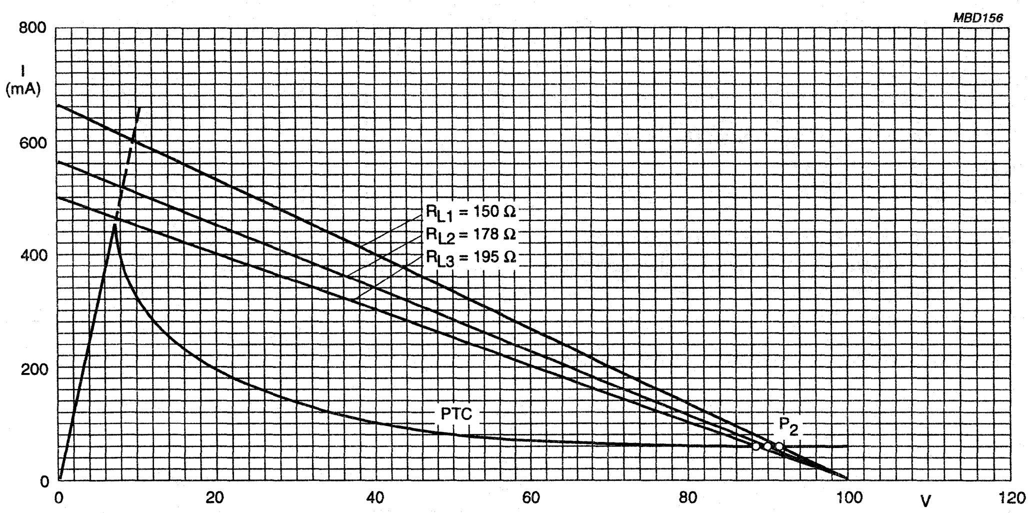


Fig.12 PTC thermistor in series with different load resistors.

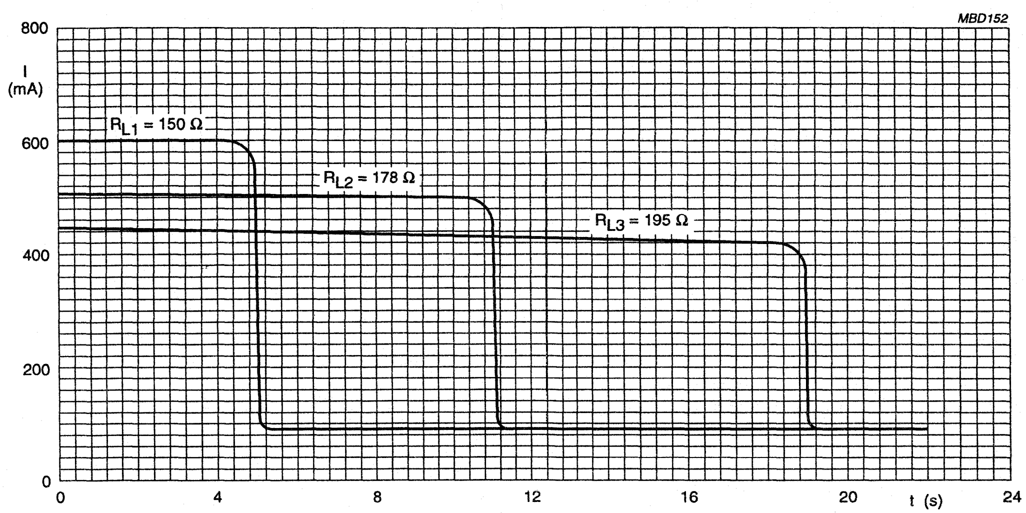


Fig.13 Current/time characteristics showing the influence of the load resistance.

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 $T_s > T_{Rmin}$ and $R_s = 2\ R_{min}$.

Temperature coefficient (α)

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

For R–T curves plotted on a logarithmic R–T scale:

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

In the product data, 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).

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

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

where:

- v is the volume of the ceramic in mm^3
- $R = (R_{25} + R_{min})/2$
- I_t is the trip current
- h is the specific heat of the ceramic; $h = (2.5 \times 10^{-3}\ J/K/mm^3)$.

The above formula is only valid for relatively short trip times (<1 minute). For longer trip times, R should be adapted to:

$$R = \frac{3}{2} \times R_{min}$$

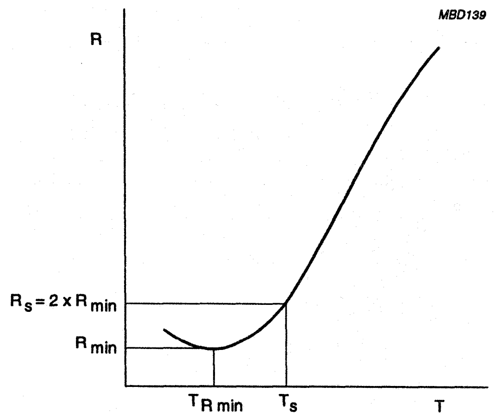


Fig.14 Switch temperature.

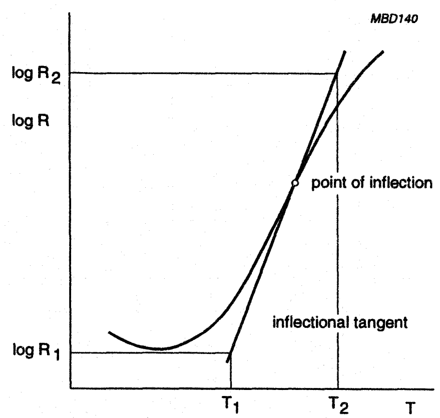


Fig.15 Temperature coefficient.

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.

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 dependency can be demonstrated by applying a pulse 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 thermistor, having no voltage dependence, and an 'ideal' VDR.

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).

These lines coincide with the PTC thermistors 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.

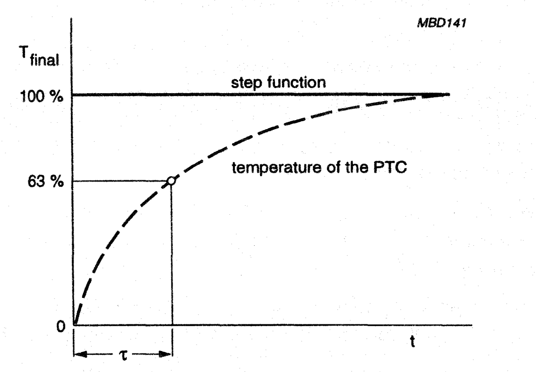


Fig.16 Thermal time constant.

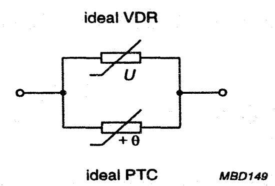


Fig.17 VDR effect.

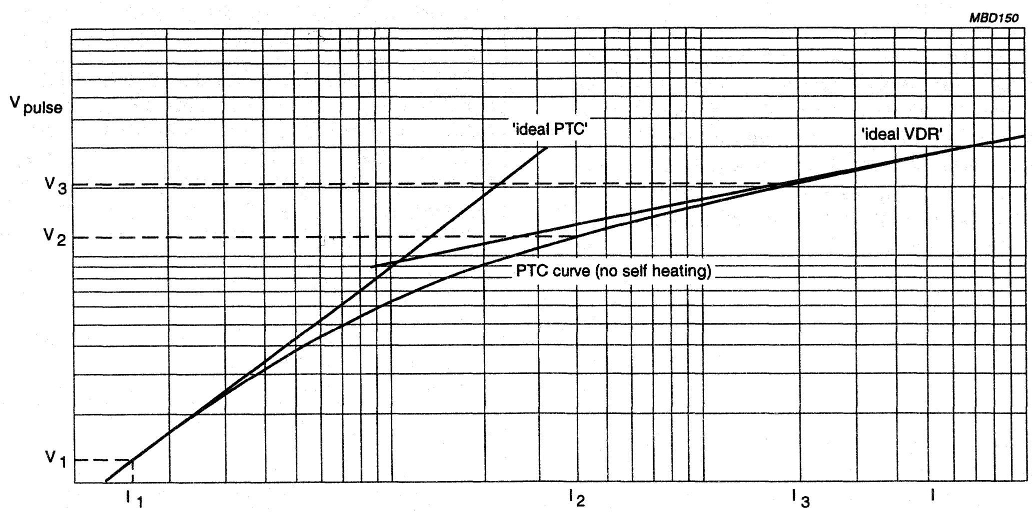


Fig.18 Relationship between an 'ideal' PTC and an 'ideal' VDR.

HOW TO MEASURE PTC THERMISTORS

Since PTC thermistors often exhibit a very high temperature coefficient, especially at high temperatures, measurement at high temperatures 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.

To prevent self-heating of the PTC thermistor the measuring current should be adapted to a low value (for example ≤1 mA).

When measuring high resistance values (for example above T_S), voltage should be limited to a maximum of 5 V.

Pulsed voltages should be used for measuring the voltage dependence of PTC thermistors, with a maximum pulse time of 20 ms to prevent self-heating.

Tolerances

The resistances of standard PTC thermistors are generally specified at:

1. 25 °C
2. 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 thermistors 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 NOTICE

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.

The manufacturer should be consulted if special PTC thermistor characteristics are required which cannot be found in this data handbook, as the requirements may be fulfilled by a non-listed device.

APPLICATIONS

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

1. Degaussing
2. Temperature protection and sensing
3. Overload (current sensitive action) protection.

These applications are based on two principles:

1. Applications where the temperature (hence the resistance) is primarily determined by the current flowing through the thermistor.
2. 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 THERMISTOR FOR A PROLONGED PERIOD OF TIME SINCE THIS MAY DESTROY THE DEVICE.
DO NOT CONNECT PTC THERMISTORS IN SERIES TO OBTAIN HIGHER VOLTAGES OR WATTAGES, SINCE THIS MAY CAUSE AN INDIVIDUAL PTC THERMISTOR TO HEAT UP FASTER THAN THE OTHER(S), RESULTING IN TOO HIGH A VOLTAGE ACROSS THE PTC THERMISTOR IN QUESTION.

GENERAL

High picture quality and colour purity have been the goals of television manufacturers for many years. Today, with recent developments in large flatscreen televisions and high definition colour monitors, achieving those goals has become essential. One area of possible improvement is in degaussing the tube. By using our dual Positive Temperature Coefficient (PTC) thermistor in the degaussing circuit, a significant improvement of picture quality can be achieved.

In addition to a steadily decaying current through the degaussing coil at switch on, the three main requirements for degaussing colour televisions and monitors are:

- High inrush current, into the degaussing coil
- Slow current decrease per half wave (long decay)
- Low residual current, after degaussing.

The larger the ratio of inrush current to residual current (degaussing ratio) the better the degaussing. Our 2322 662 96724 dual PTC, for example, has a degaussing ratio of 10000, resulting in excellent inrush current with a residual current of less than 2 mA peak-to-peak. These basic features, together with a long smooth decay can demagnetize even the largest picture tubes. As inventors and leaders in dual PTC thermistors, we have perfected their manufacture and acquired a comprehensive knowledge of optimizing degaussing circuits.

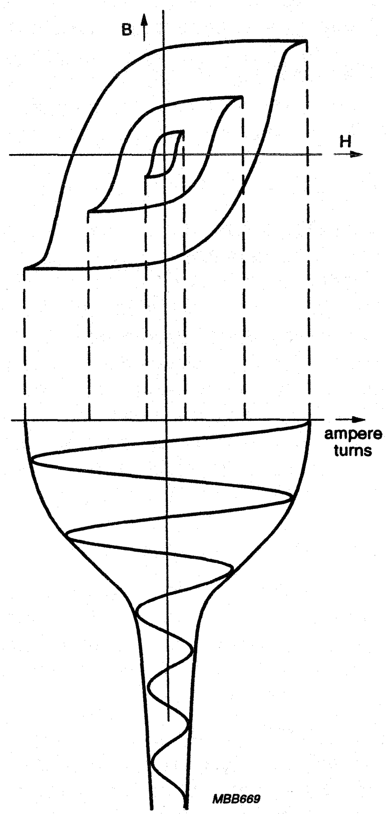


Fig.1 Typical BH curve of shadow mask and corresponding ampere-turns in the degaussing coil.

WHAT IS DEGAUSSING?

To minimize picture distortion and beam landing error (colour impurity), the shadow mask, and associated metal parts of the tube, must be demagnetized at switch on. This is done by passing decaying AC through the degaussing coil. An alternating magnetic field is generated, which gradually decays to demagnetize the tube; see Fig.4.

Degaussing with mono PTC thermistors

Connecting a PTC thermistor (mono PTC) in series with the AC mains and degaussing coil (see Fig.2) is the simplest method of producing the required decaying current. At switch on, the PTC thermistor is cold and has low resistance, so a large inrush current (I_{INR}) flows through the degaussing coil; see Fig.4. As both the temperature, and therefore the resistance of the PTC thermistor increase, the current and magnetic field decay. The PTC temperature stabilizes after a few minutes, leaving a small alternating residual current (I_{RES}) flowing through the degaussing coil; see Fig.4.

Degaussing with dual PTC thermistors

To avoid picture distortion with large-screen televisions and high-resolution colour monitors, it is crucial that the residual current, and hence the residual magnetic field, be as low as possible. A dual PTC thermistor in the degaussing circuit achieves this.

The degaussing PTC is connected in series with the degaussing coil; see Fig.3. The heater PTC, with a higher R_{25} resistance (resistance at 25 °C), is in parallel with the mains supply. At switch on, the inrush current through the degaussing coil is high, raising the temperature and resistance of the degaussing PTC. The temperature of the heater PTC also increases and its heat is dissipated towards the degaussing PTC. This further increases the degaussing PTC resistance, so further reducing the residual current. To maximize this heating effect, and thereby minimize the residual current, we carefully match the two thermistors and clamp them in close thermal contact inside a PBTP (polybutyleneteraphthalate) housing.

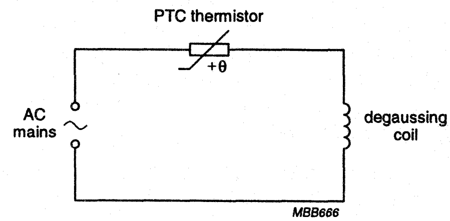


Fig.2 Mono PTC arrangement.

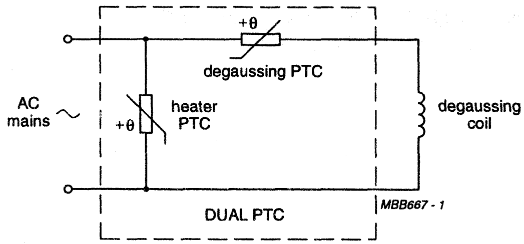


Fig.3 Dual PTC arrangement.

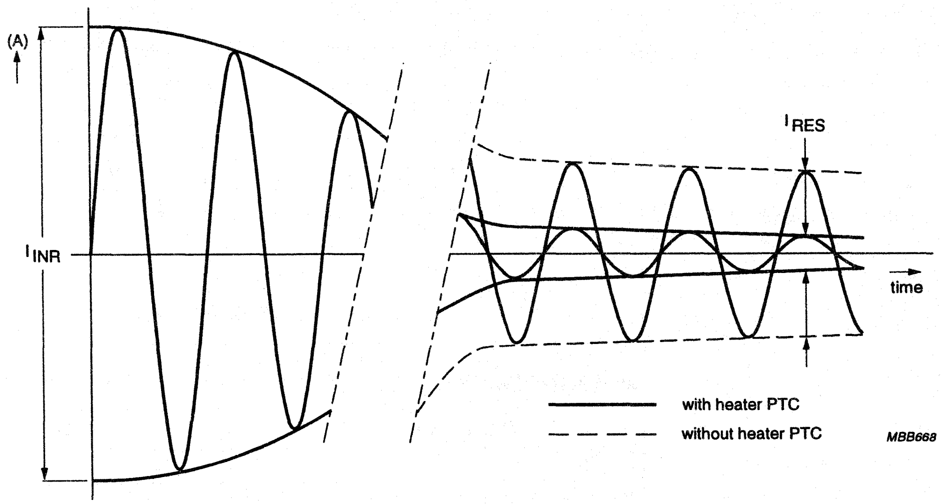
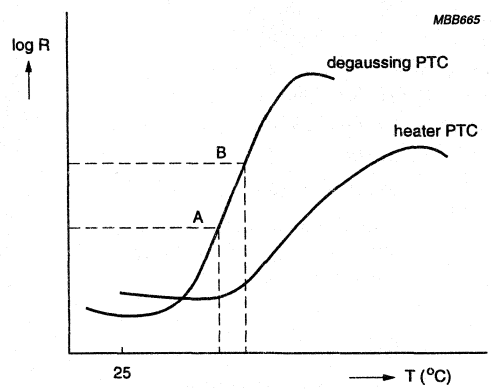


Fig.4 By using a dual PTC thermistor, I_{RES} is significantly reduced.



Resistance stabilizes at point A without the heater PTC and at point B with the heater PTC.

Fig.5 Typical R-T characteristics for a dual PTC.

PTC thermistors for degaussing 2322 662 96...

FEATURES

- Residual currents as low as 1 mA, ideal for high-resolution displays
- Long decay time
- Stable performance over a long time
- Non-flammable (*"UL 94.V.0"*)
- Silver migration resistant
- Design-in support available.

APPLICATIONS

- Colour televisions
- Colour monitors.

DESCRIPTION

For good picture definition, colour televisions and monitors must be degaussed by a strong alternating magnetic field which gradually and symmetrically decays to a small value of residual current. This can be achieved by connecting a PTC thermistor in the degaussing circuit.

The new generation of flat-screen, high-definition colour televisions and monitors require an excellent picture quality with high colour purity. This can only be achieved by a dual PTC device housing two PTC thermistors in intimate thermal contact, one being used to heat the other and so further reduce the residual current.

MARKING

If assembled in Belgium the thermistors are marked with the following information:

- The last five digits of the catalogue numbers
- Manufacturer's code of identification
- Date of manufacture, 5 digits denoting year, week and day number (yywwd).

If assembled in Singapore the thermistors are marked with the following information:

- Manufacturer's code of identification
- The last five digits of the catalogue numbers
- Assembler (SP)
- Date of manufacture, 5 digits denoting year, week and day number (yywwd).

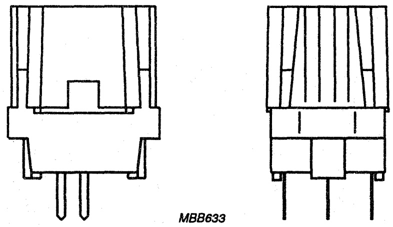


Fig.1 Component outline.

QUICK REFERENCE DATA

PARAMETER	VALUE
Solderability	≤4 s at 240 °C
Resistance to heat	≤11 s at 265 °C
Operating temperature range:	
at zero power	−25 to +125 °C
at maximum voltage	0 to 60 °C
Drop test:	
height of free fall	1 m

PACKAGING

The thermistors are supplied in cardboard boxes, each box containing 600 units.

CAPABILITY

According to customer requirements, the following three ranges are available:

Standard range:

Minimum inrush current <25 A (p-p) with typical coil.

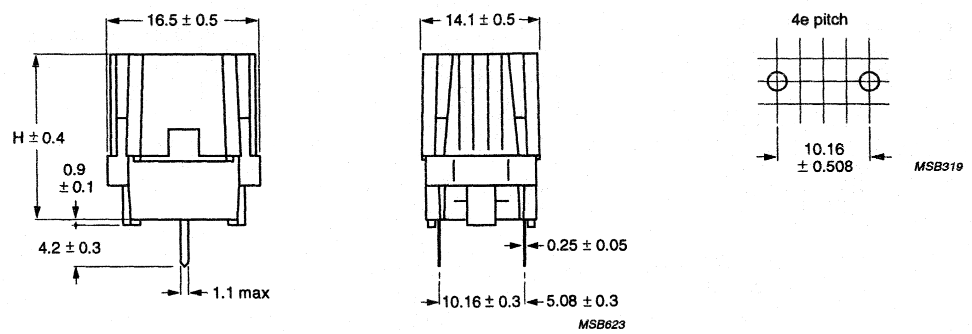
High inrush range:

Minimum inrush current >25 A (p-p) with typical coil.

Long decay:

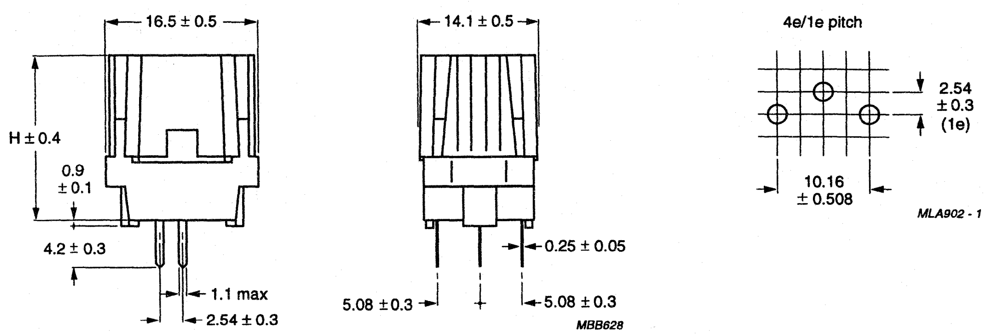
Typical decay time >70 ms with typical coil.

MECHANICAL DATA



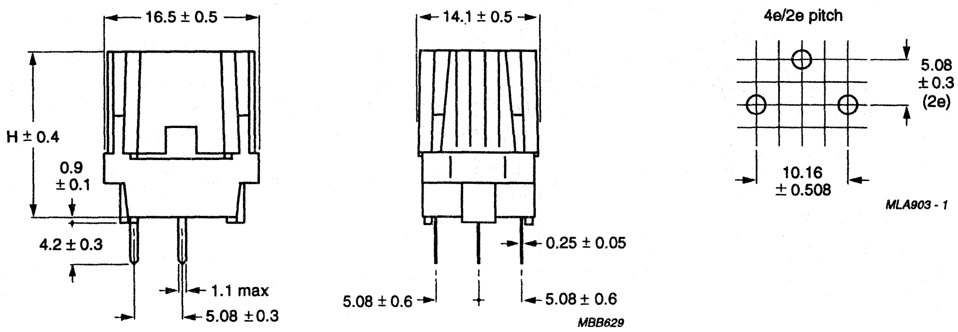
Dimensions in mm.
For low cap housing, H = 18.4 mm.
For high cap housing, H = 20.4 mm.

Fig.2 Mono PTC pin configuration 4e pitch.



Dimensions in mm.
For low cap housing, H = 18.4 mm.
For high cap housing, H = 20.4 mm.

Fig.3 Dual PTC pin configuration 4e/1e pitch.



Dimensions in mm.
For low cap housing, H = 18.4 mm.
For high cap housing, H = 20.4 mm.

Fig.4 Dual PTC pin configuration 4e/2e pitch.

ELECTRICAL DATA AND ORDERING INFORMATION

Dual Range

Table 1 Electrical data and catalogue numbers. Preferred types in **bold**.

CATALOGUE NUMBER 2322 662 ..... notes 1, 2 and 3	MINIMUM PEAK-TO-PEAK INRUSH CURRENT (A)		MAXIMUM PEAK-TO-PEAK RESIDUAL CURRENT (after 180 s) (mA)		R_{25} (Ω)	R_{coil} (Ω)		U_{max} (RMS) (V)	REPLACED CATALOGUE NUMBER 2322 662 .....
	220 V (AC)	110 V (AC)	220 V (AC)	110 V (AC)		MIN.	TYP.		
Standard inrush current									
96209; 96X09	11	5.2	4	2	30	17	25	276	96009
96211; 96X11	14	6.6	2	2	26	14	17	276	96011 96111
96216; 96X16	16	7.2	4	2	22	14	17	276	96016
96624; 96Y24	20	9.0	2	2	18	10	13	276	96124 96524
96Y02	25	12	4	4	14	10	10	276	96502
96X13	–	22	–	10	7	3	5	145	96013 96125
Long decay									
96Y16	16	7.2	2	2	22	14	17	276	96116
96Y26	18	8.2	2	2	18	13	17	276	96123 96126 96526
High inrush current									
96706	28	14	5	4	12	10	10	276	–
96705	–	36	–	14	5	1	3	145	–

Notes

1. Cap = top part of plastic housing.
2. Pitch 4e/1e:
   a) For low cap, replace X in catalogue number by 2
   b) For high cap, replace Y in catalogue number by 6.
3. Pitch 4e/2e:
   a) For low cap, replace X in catalogue number by 3
   b) For high cap, replace Y in catalogue number by 7.

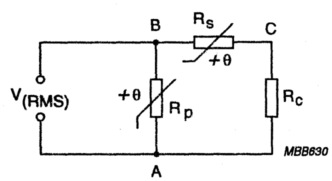
Mono Range

Table 2 Electrical data and catalogue numbers

CATALOGUE NUMBER 2322 662 ..... note 1	MINIMUM PEAK-TO-PEAK INRUSH CURRENT (A)		MAXIMUM PEAK-TO-PEAK RESIDUAL CURRENT (after 180 s) (mA)		R_{25} (Ω)	R_{coil} (Ω)		U_{max} (RMS) (V)
	220 V (AC)	110 V (AC)	220 V (AC)	110 V (AC)		MIN.	TYP.	
96281	11	5.2	20	30	30	17	25	276
96682	20	9.0	25	30	18	10	13	276
96683	25	12	30	40	14	10	10	276
96684	21	10.2	30	40	12	10	10	276
96285	–	22	–	40	7	3	5	145
96686	–	32	–	50	5	1	4	145
96687	20	10	30	35	9	20	20	276
96688	12.8	5.8	20	30	26	14	25	276

Note

1. Catalogue numbers 2322 662 96281 and 2322 662 96285 are produced with a low cap; all other catalogue numbers have a high cap.



R_s = resistance of series PTC.
R_p = resistance of parallel PTC.
R_c = replaces the degaussing coil (Z = 25 W).

Fig.5 Measuring circuit.

PTC Thermistors

Introduction to PTC temperature protection and sensing

FEATURES

- Well-defined protection temperature levels
- Very fast reaction time
- Accurate resistance for ease of circuit design
- Stable over a long life
- Wide range of protection temperatures
- No need to reset supply after overtemperature switch
- Small size and rugged
- Naked and leaded devices available
- High voltage insulation and excellent thermal coupling.

APPLICATIONS

- Industrial electronics
- Power supplies
- Electronic data processing.

DESCRIPTION

Negative Temperature Coefficient (NTC) thermistors are well known for temperature sensing. What is not well known, however, is that Positive Temperature Coefficient (PTC) thermistors can be used for thermal protection. Although their operating principles are similar, the applications are very different; whereas NTC thermistors sense and measure temperature over a defined range, PTC thermistors switch at one particular temperature. Just like thermostats they protect such equipment and components as motors, transformers, power transistors and thyristors against overtemperature. A PTC thermistor is less expensive than a thermostat, and its switch temperature can be more accurately specified. It is also smaller and easier to design-in to electronic circuitry.

So how does it work? The PTC thermistor is mounted in thermal contact with the equipment to be protected, and connected into the bridge arm of a comparator circuit, such as shown in Fig.1. At normal temperature, the PTC thermistor resistance (R_p) is lower than R_s (see Fig.2), so the comparator's output voltage V_O will be low. If an equipment overtemperature occurs, the PTC thermistor will quickly heat up to its switch temperature T_n, whereupon its resistance will switch to a value much higher than R_s, causing V_O to increase to a level sufficient to activate a trip or alarm.

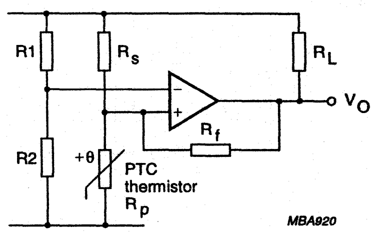


Fig.1 Typical comparator circuit.

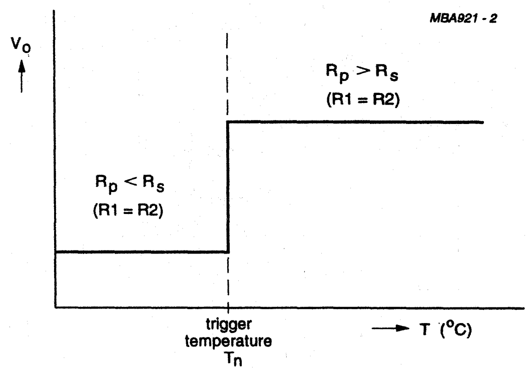
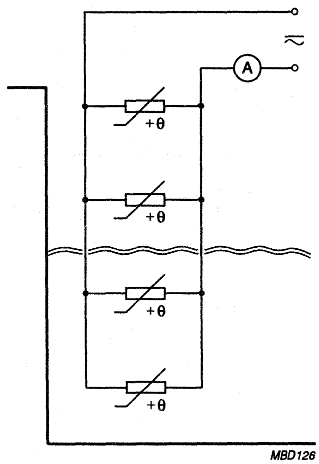


Fig.2 Typical switch characteristic.

APPLICATION EXAMPLES



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

Fig.3 Liquid-level indication.

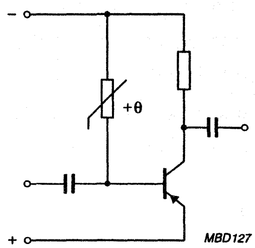
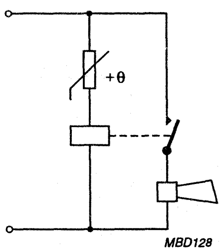
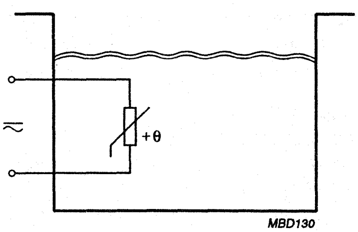


Fig.4 Temperature compensation of transistor circuits.



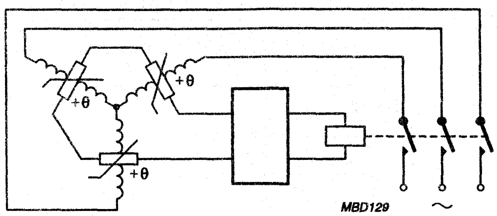
The PTC reacts to ambient temperature (too low or too high).

Fig.5 Alarm installation.



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

Fig.6 Thermostatically controlled heating circuit.



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

Fig.7 Temperature protection of electric motors.

PTC thermistors for temperature protection 2322 671 91...

FEATURES

- Very fast action for maximum protection
- Well defined protection levels
- Well defined resistance for ease of circuit design
- Coated and leaded devices available
- High sensitivity to small temperature changes
- Excellent long term behaviour.

APPLICATIONS

- Industrial electronics
- Power supplies
- Electronic data processing.

DESCRIPTION

These directly heated thermistors have a positive temperature coefficient and are primarily intended for sensing.

QUICK REFERENCE DATA

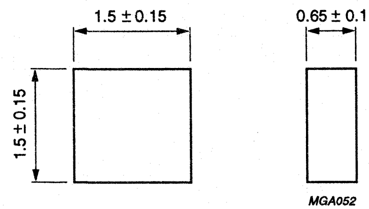
PARAMETER	VALUE	UNIT
Maximum resistance at 25 °C	120	Ω
Minimum resistance at (T_n + 15) °C and 7.5 V_{pulse}	4000	Ω
Maximum (DC) voltage	30	V
Temperature range	0 to (T_n + 15)	°C
Weight:		
91052 to 91067	≈0.008	g
91002 to 91014	≈0.013	g
91102 to 91114	≈0.08	g
Climatic category	25/125/56	

PACKAGING INFORMATION

PACKAGING		CATALOGUE NUMBERS 2322 ... .
S.P.Q.	P.Q.	
5000	20000	671 91052 to 671 91067
5000	20000	671 91002 to 671 91014
500	6000	671 91102 to 671 91114

PTC thermistors for temperature protection 2322 671 91...

MECHANICAL DATA

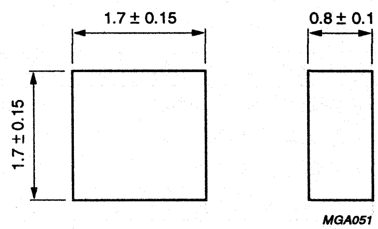


Dimensions in mm.

For clamping, reflow or hand soldering. Not intended for either wave or ultrasonic soldering and not for spot welding.

All standard solder alloys with low activated halogene-free fluxes are acceptable, for example: 62Sn/36Pb/2Ag.

Fig.1 Component outline for 91052 to 91067.

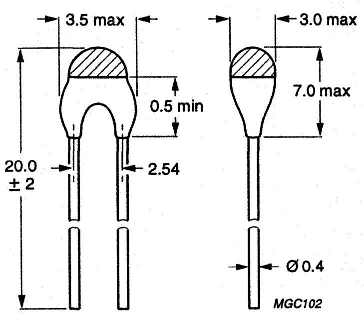


Dimensions in mm.

For clamping, reflow or hand soldering. Not intended for either wave or ultrasonic soldering and not for spot welding.

All standard solder alloys with low activated halogene-free fluxes are acceptable, for example: 62Sn/36Pb/2Ag.

Fig.2 Component outline for 91002 to 91017.



Dimensions in mm.

Fig.3 Component outline for 91102 to 91114.

PTC thermistors for temperature protection 2322 671 91...

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUES
Maximum resistance at 25 °C	120 Ω
Maximum resistance at (T_n – 5) °C:	
2322 671 91052 to 91067	see Table 1
2322 671 91002 to 91014	see Table 1
2322 671 91102 to 91114	see Table 1
Minimum resistance at (T_n + 15) °C and 7.5 V_{pulse}	4000 Ω
Minimum resistance at (T_n + 5) °C:	
2322 671 91052 to 91067	see Table 1
2322 671 91002 to 91014	see Table 1
2322 671 91102 to 91114	see Table 1
Maximum voltage	30 V (DC)

Table 1 Nominal working temperatures and ordering information

NOMINAL WORKING TEMPERATURE					TYPE/CATALOGUE NUMBER 2322			
					NAKED CHIP(1)		LEADED DEVICE	
T_n (°C)	30 to 250 Ω from –20 °C to T (°C)	50 to 550 Ω at T (°C)	1.33 to 50 kΩ at T (°C)	>4 kΩ at T (°C)	1.5 × 1.5 mm 671	1.7 × 1.7 mm 671	671	COLOUR CODE
70	50	65	75	85	91052(2)	91002(2)	91102(2)	black
80	60	75	85	95	91053	91003	91103	brown
90	70	85	95	105	91054	91004	91104	red
100	80	95	105	115	91055	91005	91105	orange
110	90	105	115	125	91056	91006	91106	yellow
120	100	115	125	130	91057	91007	91107	green
125	105	120	130	135	91058	–	–	–
130	110	125	135	140	91059	91009	91109	blue
135	115	130	140	145	91061	–	–	–
140	120	135	145	150	91062	91012	91112	violet
145	125	140	150	155	91063	–	–	–
150	130	145	155	160	91064	91014	91114	grey
155	135	150	160	165	91065	–	–	–
160	140	155	165	170	91066	–	–	–
170	150	165	175	175	91067	–	–	–

Notes

1. Naked chips are packed in a hermetically-sealed alu-plastic bag.
2. R at 25 °C: 30 to 120 Ω.
   R at T_n – 5 °C: 50 to 570 Ω.
   R at T_n + 5 °C: 570 to 25000 Ω.
   For all other types, R_{25} is between 30 and 120 Ω.

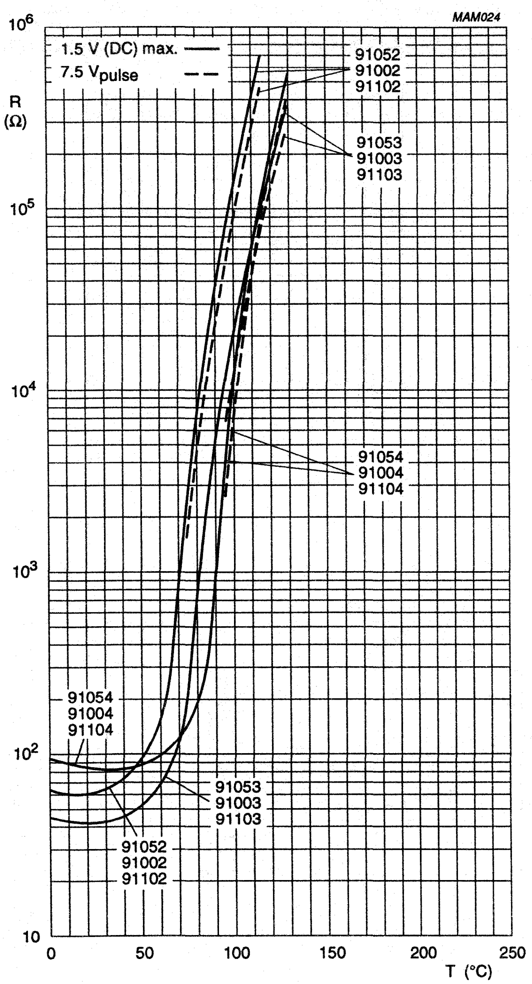


Fig.4 Typical resistance/temperature characteristic for 2322 671 91052/002/102, 91053/003/103 and 91054/004/104.

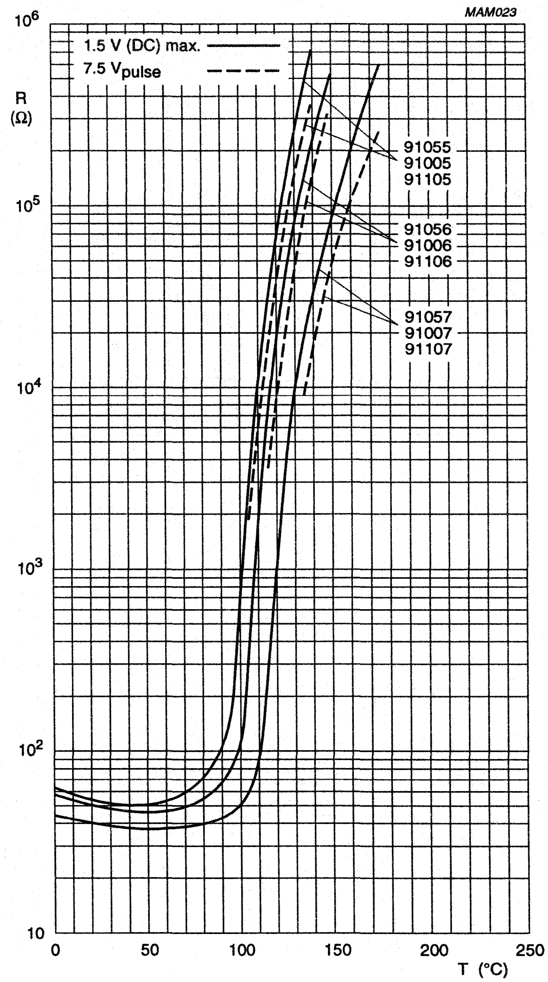


Fig.5 Typical resistance/temperature characteristic for 2322 671 91055/005/105, 91056/006/106 and 91057/007/107.

PTC thermistors for temperature protection 2322 671 91...

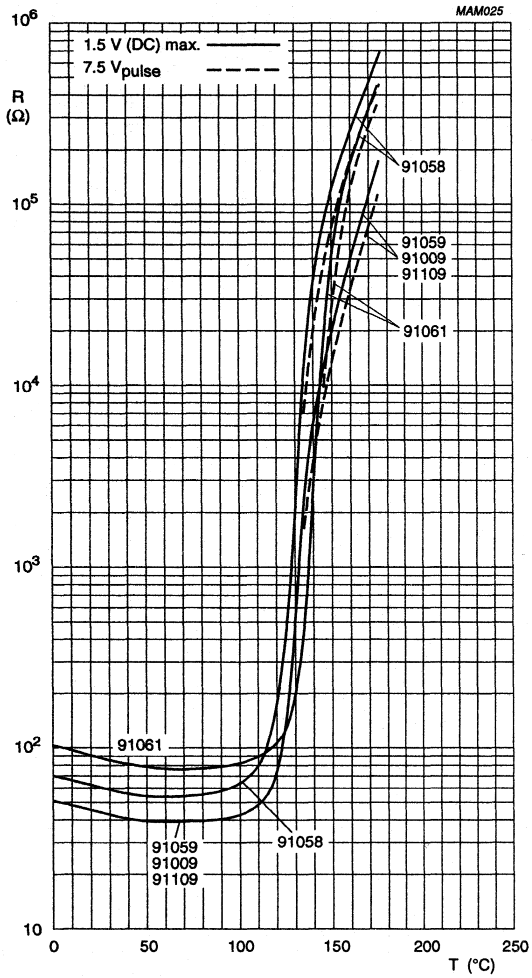


Fig.6 Typical resistance/temperature characteristic for 2322 671 91058, 91059/009/109 and 91061.

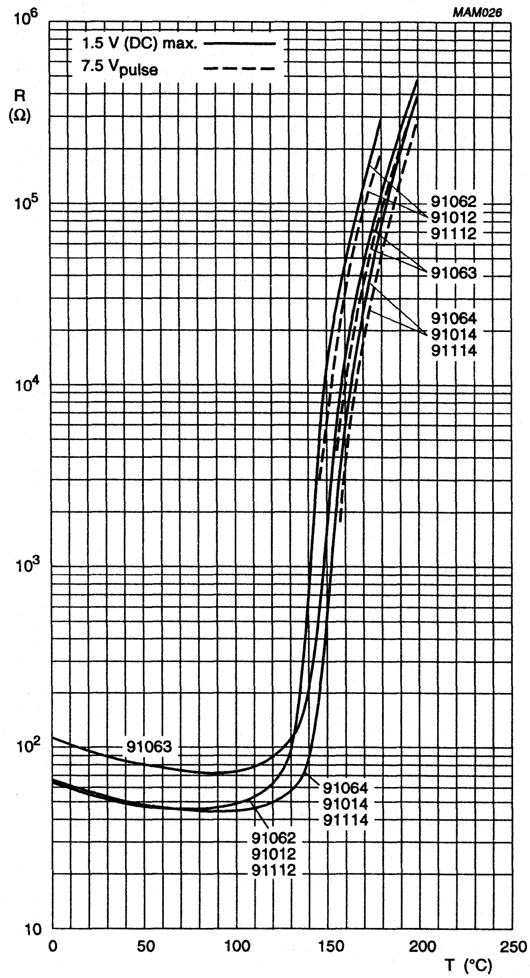


Fig.7 Typical resistance/temperature characteristic for 2322 671 91062/012/112, 91063 and 91064/014/114.

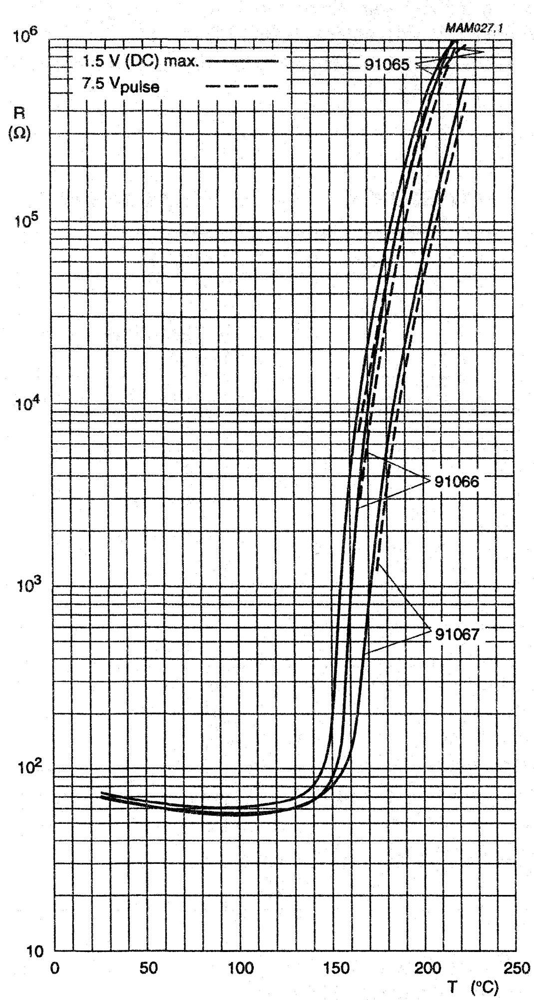


Fig.8 Typical resistance/temperature characteristic for 2322 671 91065, 91066 and 91067.

TEST AND REQUIREMENTS

Clause numbers of tests and performance requirements refer to the *"CECC draft secretariat 2371 (January 1989)"*. AQLs are selected from *"IEC 410"*. Tables with requirements for lot by lot and periodic tests. In these tables:
D = Destructive
ND = Non-destructive.

Acceptable quality level

CECC CLAUSE	TEST	D or ND	PROCEDURE	REQUIREMENTS
Group A inspection (lot by lot)				
SUB-GROUP A1		ND		
4.3.1	visual examination			no defect likely to impair function
4.3.3	dimensions (gauging)			as specified
SUB-GROUP A2		ND		
4.4	zero power resistance		temperature: 25 °C $(T_n - 5)$ °C $(T_n + 5)$ °C $(T_n + 15)$ °C and 7.5 V_{pulse}	≤120 Ω as specified as specified ≥4000 Ω
Group B inspection (lot by lot)				
SUB-GROUP B1		D		
4.13.1	soldering, solderability		for 2322 671 91052 to 91067 and 91002 to 91017: solder bath: 60/40; 260 ±5 °C and RMA flux; duration: 30 s for 2322 671 91102 to 91114 and 91102 to 91114: solder bath method: 235 ±5 °C	75% of surface covered with solder the terminations shall be evenly tinned
Group C inspection (periodic)				
SUB-GROUP C1		D		
4.12	robustness of terminations		for 2322 671 91102 to 91114: test Ua (10 N) and test Ub (5 N) of *"IEC 68-2-21"* visual examination zero power resistance at 25 °C	 as in 4.12.4; see note 1 ΔR/R ≤±10%
4.13.2	resistance to soldering heat		for 2322 671 91102 to 91114: test Tb of *"IEC 68-2-20A"* visual examination zero power resistance at 25 °C	 as in 4.13.2.3 ΔR/R ≤±10%

PTC thermistors for temperature protection 2322 671 91...

CECC CLAUSE	TEST	D or ND	PROCEDURE	REQUIREMENTS
4.14	rapid change of temperature		for 2322 671 91052 to 91067, 91002 to 91017 and 91102 to 91114: test Na of *"IEC 68-2-14"*	
			T_A: lower category temperature = −25 °C	
			T_B: upper category temperature = +125 °C	as in 4.14.4
			5 cycles	ΔR/R ≤±10%
			visual examination	as in 4.14.4
			zero power resistance at 25 °C	ΔR/R ≤±10%
4.18	climatic sequence:		low air pressure test not applicable	
	dry heat			
	damp heat, cyclic, first cycle			
	cold			
	damp heat, cyclic, remaining cycles		visual examination	as in 4.18.7.1
	final measurements		zero power resistance at 25 °C	ΔR/R ≤±10%
SUB-GROUP C2		D		
4.20.3	endurance at maximum rated temperature		duration: 24 hours at (T_n + 15) °C and 30 V (DC)	
			examination: at 24 hours	
			visual examination	as in 4.20.3.10
			zero power resistance at 25 °C	ΔR/R ≤±10%
SUB-GROUP C3		D		
4.19	damp heat, steady state		visual examination	as in 4.19.5
			zero power resistance at 25 °C	ΔR/R ≤±10%
SUB-GROUP C4		D		
4.20.2	endurance at upper category temperatures		for 2322 671 91002 to 91017 and 91052 to 91067: duration 168 hours at 200 °C	
			for 2322 671 91102 to 91114: duration 168 hours at 150 °C	
			for 2322 671 91002 to 91017, 91052 to 91067 and 91102 to 91114: duration 1000 hours at 125 °C	
			examination: at 168, 500 and 1000 hours	
			visual examination	as in 4.20.2.7
			zero power resistance at 25 °C	ΔR/R ≤±5%

Note

1. No loose or broken leads.

PTC thermistors

Introduction to PTC overload protection

FEATURES

- Fast-acting for reliable protection time and time again
- Well-defined protection trip levels
- Low, medium and high voltage ratings
- No need to reset supply after overload
- Stable over a long life
- No current adjustment necessary
- No RF noise generated
- Small size
- Leadless and leaded versions available
- Customized design, particularly for telecommunication application.

APPLICATIONS

Applications are wide, varied and include the following:

General industries

- Transformers
- Delay lines
- Rechargeable batteries
- Switched-mode power supplies
- Measuring equipment.

Automotive systems

- Wiper motors
- Gear boxes
- Air flow controls
- Window motors
- Car door lock defrosting systems.

Consumer electronics

- Loudspeaker boxes
- Video recorders, compact disc players and stereo equipment
- Electronic lighting ballast
- Colour televisions.

Domestic appliances

- Boilers
- Shaver socket transformers
- Coffee grinders
- Hobby tools
- Ice makers
- Washing machines.

Telecommunications

- Line protection
- Regulation of telephones, facsimiles and modems
- Integrated services data network (ISDN).

DESCRIPTION

As market leaders in ceramics technology, Philips Components offer a comprehensive selection of thermistors. For overload protection of equipment such as motors, transformers, lamps, rechargeable batteries and power supplies, we offer a full range of Positive Temperature Coefficient (PTC) thermistors. They provide reliable protection time and time again, opposed to a normal fuse, which is usually destroyed by the first overload.

PTC thermistors have well-defined trip and non-trip currents and react quickly to overloads. Low, medium and high voltage ratings make them suitable for a wide range of applications, from low-voltage automotive systems to worldwide mains circuits. Selection is easy, simply choose the voltage rating and the required trip or non-trip current.

MECHANICAL OPTIONS

PTC thermistors are available in the following versions:

- Leadless discs, metallized for clamp-contacting
- Leaded devices, bulk-packed or taped on reel (suitable for automatic insertion).

HOW PTC THERMISTORS PROTECT AGAINST OVERLOADS

When connected in series with the input of an electrical or electronic circuit (see Fig.1), such as a small motor or power supply, the PTC thermistor acts as a non-destructive fuse, protecting the circuit against current, voltage and temperature overloads.

Normally the thermistor resistance is low (see Fig.2), and the current is below its non-trip (I_{nt}) value. However, an overload will quickly heat up the PTC thermistor until, at around the switch temperature (T_s), its resistance becomes high, limiting the current to below its trip value (I_t), and so protecting the circuit.

Removing the overload or switching off the supply allows the PTC thermistor to cool down and return to its low-resistance state, ready to resume its protective function.

Figure 3 shows the PTC thermistor I/V characteristic (ABD) superimposed on the load-line (CD). The circuit will be designed such that, under normal conditions, the load-line (CD) lies below point B, the top of the thermistor I/V characteristic. Under this condition the PTC thermistor resistance is low, so most of the voltage (V) will appear across the load R_{L1}. Under an overload condition R_{L2}, the load-line (CD) will move above point B. The PTC thermistor will switch to its high-resistance state (BE) and the overload current will heat up the PTC thermistor to its overload working point (E). The PTC thermistor will therefore absorb the overload current and protect the load.

There are in fact, three overload possibilities:

1. Overcurrent (see Fig.3), where the load current increases due to a decrease in load resistance, for example when a motor winding short-circuits.
2. Overvoltage (see Fig.4), caused for example, when the 220 V mains is accidentally applied to a 115 V mains appliance.
3. Overtemperature (see Fig.5), where the PTC thermistor is in intimate thermal contact with an overheating load (T_{amb2}). Here, due to external heating the PTC thermistor needs less external energy to reach its switch point B, so B2 moves below the load-line CD.

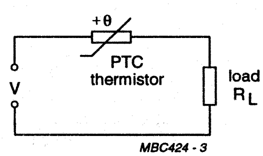


Fig.1 Typical circuit.

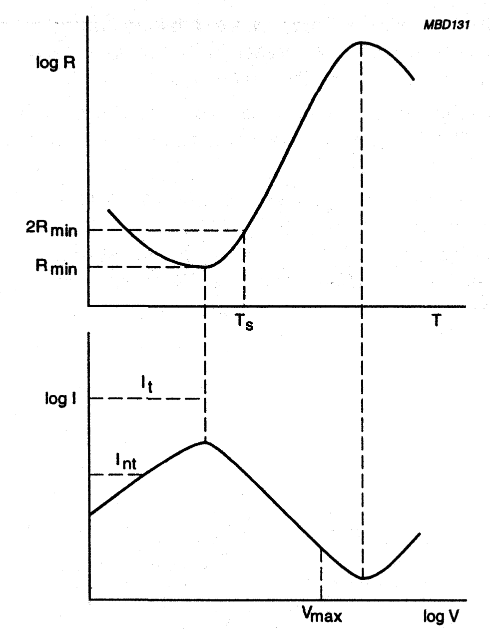


Fig.2 PTC thermistor characteristics.

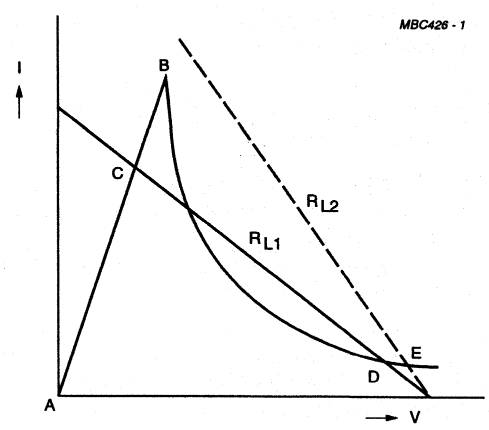


Fig.3 Overcurrent protection.

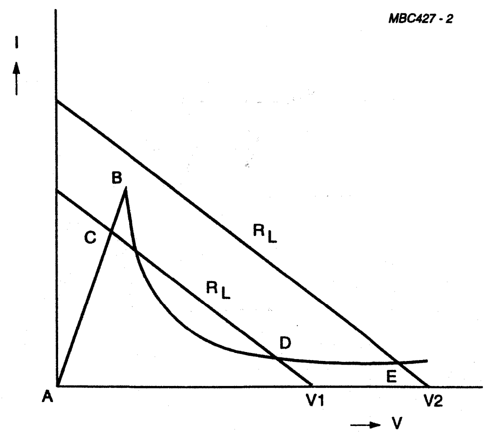


Fig.4 Overvoltage protection.

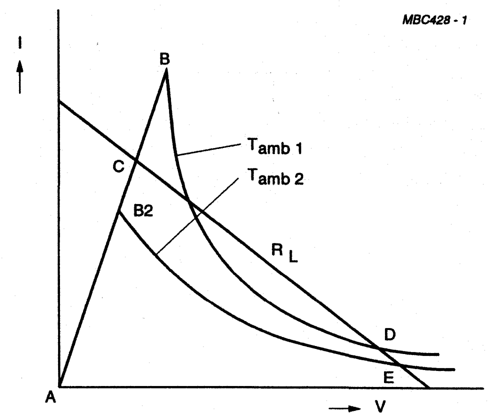
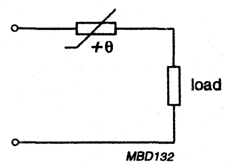


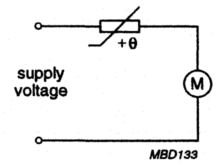
Fig.5 Overtemperature protection.

APPLICATION EXAMPLES



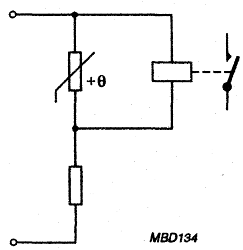
As soon as the current increases, the PTC limits it to a safe value.

Fig.6 Current limiting.



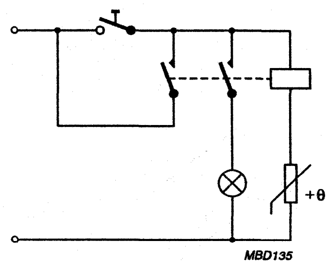
The increased current heats the PTC to its switch temperature. As a result, the total dissipated power is reduced to a safe value. The example shown could also be used as protection against overheating in transformers, lamps, printed-circuit boards, rechargeable batteries, power supplies, etc.

Fig.7 Protection of a stalled electric motor against overheating.



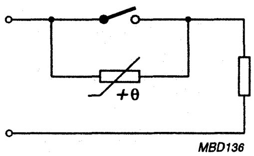
After applying the voltage for a certain time period, the relay is activated.

Fig.8 Delaying action of relays.



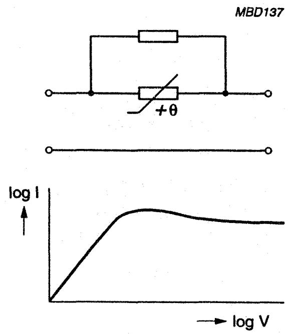
When the switch is operated, the relay is activated and the lamp is illuminated. After a certain time period, the relay is de-activated due to the increase in resistance of the PTC.

Fig.9 Time delay circuit.



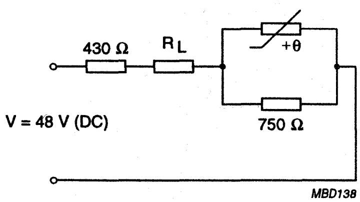
A PTC fitted in parallel with the switch acts as a spark suppressor. When the switch opens, the low resistance of the PTC prevents sparking.

Fig.10 Spark suppression circuit.



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

Fig.11 Current stabilization.



One very useful application is the use of this circuit to provide line resistance compensation for variations in telephone lines.

Fig.12 Line resistance (R_L) compensation.

Thermistors for overload protection PTC 56 V and 265 V (T_S = 120 °C)

2322 66. 0/1/3.... series

FEATURES

- Different voltages to be chosen in function of the application
- Available in three mechanical versions
  - 2322 66. 0.... naked discs
  - 2322 66. 1.... leaded
  - 2322 66. 3.... taped, on reel (to diameter 12.5 mm)
- Wide range of trip and non-trip currents: from 17 mA up to 3 A for the trip current
- Wide range of resistance: from 1.6 Ω up to 1.9 kΩ
- Small ratio between trip and non-trip currents ($I_t/I_{nt} \leq 1.5$ at 25 °C) $\left(\frac{I_t \text{ (at 10 °C)}}{I_{nt} \text{ (at 55 °C)}} = 2\right)$
- Leaded parts withstand mechanical stresses and vibration.

APPLICATIONS

- Telecommunications
- Automotive systems
- Industrial electronics
- Consumer electronics
- Electronic data processing.

DESCRIPTION

These directly heated thermistors have a positive temperature coefficient and are primarily intended for overload protection. They consist of a naked disc or with two tinned brass leads.

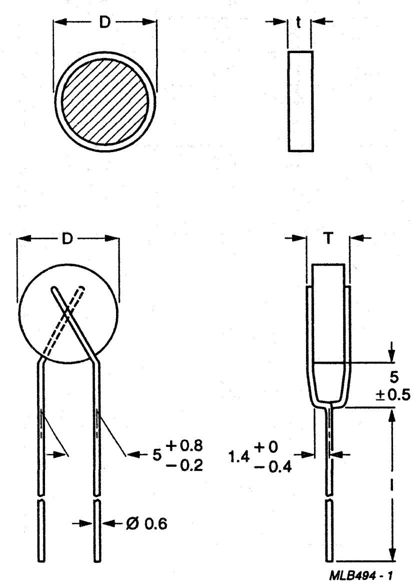
QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Switch temperature; note 1	140	°C
Maximum voltage:		
2322 66. 0/1/3...1	56	V (DC)
2322 66. 0/1/3...3	265	V (RMS)
Temperature range:		
2322 66. 0/1/3...1/3 at zero dissipation	−25 to 125	°C
2322 66. 0/1/3...1/3 at V_{max}	0 to +70	°C
Climatic category	25/125/56	

Note

1. For information only.

MECHANICAL DATA



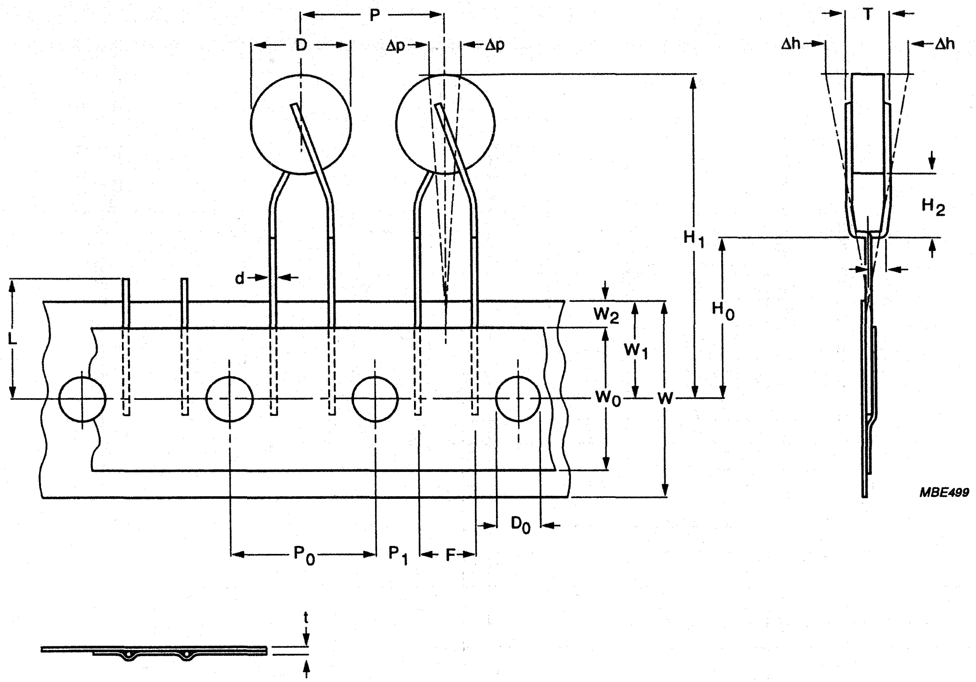
Dimensions in mm.
For D, T and t see Table 1.

Fig.1 Component outline for 2322 66. 0/1...1

Table 1 Device dimensions, packaging and catalogue numbers

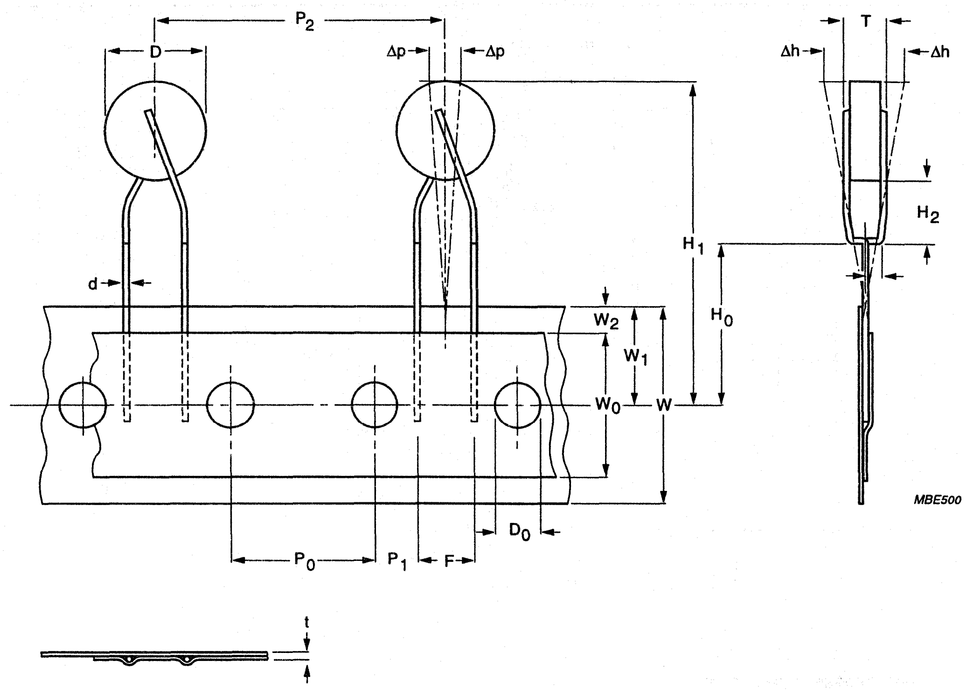
D TYP. (mm)	t ±10% (mm)	T MAX. (mm)	PACKAGING			CATALOGUE NUMBERS 2322 ... .
			NAKED	LEADED BULK	LEADED TAPED	
4.5	1.6	4.0	Fig.1	Fig.1	Fig.2	660 .5691; 660 .6891; 660 .8291
	2.6	5.0				660 .1293; 660 .1593; 660 .1893; 660 .2293; 660 .2793
6.5	1.6	4.0	Fig.1	Fig.1	Fig.2	661 .1011; 661 .1211
	2.6	5.0				661 .3393; 661 .3993; 661 .4793; 661 .5693
8	1.6	4.0	Fig.1	Fig.1	Fig.2	661 .1511
	2.6	5.0				661 .6893; 661 .8293; 661 .1013
10	2.0	4.5	Fig.1	Fig.1	Fig.2	662 .1811
	2.6	5.0				662 .1213
12	2.0	4.5	Fig.1	Fig.1	Fig.3	662 .2211; 662 .2711
	2.6	5.0				662 .1513; 662 .1813
13	2.6	5.0	Fig.1	Fig.1	Fig.3	663 .3311; 663 .2213
16	2.6	5.0	Fig.1	Fig.1	Fig.3	663 .3911; 663 .4711; 663 .2713
20	3.2	6.0	Fig.1	Fig.1	Fig.3	664 .5611; 664 .6811; 664 .3313; 664 .3913; 664 .4713

Thermistors on tape



Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

Fig.2 Thermistors with ØD < 12 mm on tape for 2322 66. 6...0/1/3.



Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

Fig.3 Thermistors with ØD ≥ 12 mm on tape for 2322 66. 6...0/1/3.

Characteristics concerning taped thermistors

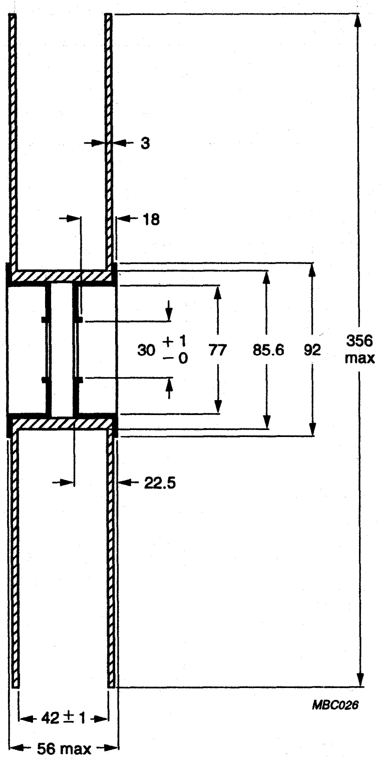
PARAMETER	VALUE
Minimum pull out force of the component	5 N
Minimum pull off force of adhesive tape	6 N
Minimum tearing force tape	15 N
Maximum pull off force tape-reel	5 N
Storage conditions	
Storage temperature range	–25 to 40 °C
Maximum relative humidity	80%

Tape and additional device information

Table 2 Tape and other device dimensions; see Figs 1, 2 and 3

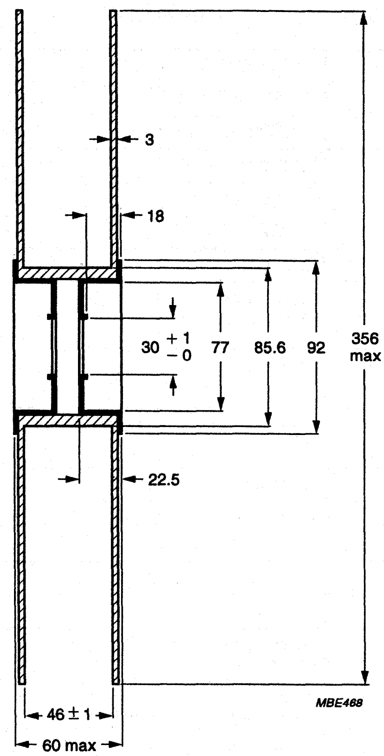
SYMBOL	PARAMETER	DIMENSIONS (mm)	TOLERANCE	REMARKS
D	body diameter:			
	2322 66. 0/1/3...1	see Table 1		
	2322 66. 0/1/3...3	see Table 1		
T	total thickness:			
	2322 66. 0/1/3...1	see Table 1		
	2322 66. 0/1/3...3	see Table 1		
d	lead diameter	0.6	±10%	
P	pitch between thermistors	12.7	±1	
P_2		25.4	±2	
P_0	feed hole pitch	12.7	±0.3	cumulative pitch error ±1 mm/20 pitches
P_1	feed hole centre to lead centre	3.81	±0.7	guaranteed between component and tape
Δp	component alignment	0	±1.3	
F	lead to lead distance	5	+0.6 to −0.1	guaranteed between component and tape
Δh	component alignment	0	±2	
W	tape width	18	+1 to −0.5	
W_0	hold down tape width	≥12.5	−	
W_1	hole position	9	±0.5	
W_2	hold down tape position	≤3.0	−	
H_1	component height	≤37	−	
H_0	lead-wire clinch height	16	±0.5	
D_0	feed hole diameter	4	±0.2	
t	total tape thickness	≤0.9	−	with cardboard tape 0.5 ±0.1 mm
L	length of snipped lead	≤11	−	

Reel information



Dimensions in mm.
ØD < 12 mm.

Fig.4 Dimensions of the reel for 2322 66. 6...0/1/3.



Dimensions in mm.
ØD > 12 mm.

Fig.5 Dimensions of the reel for 2322 66. 6...0/1/3.

PACKAGING INFORMATION

PACKAGING		CATALOGUE NUMBERS	
S.P.Q.	P.Q.	FIRST 7 DIGITS	LAST 5 DIGITS
5000	20000	2322 660	0...1
500	10000		1...1
3000	3000		3...1
3000	12000		0...3
500	10000		1...3
3000	3000		3...3
5000	5000	2322 661	0...1
250	5000		1...1
3000	3000		3...1
3000	3000		0...3
250	5000		1...3
3000	3000		3...3
4000	4000	2322 662	0...1
200	4000		11811
100	2000		12211–12711
1500	1500		31811
3000	3000		32211–32711
3000	3000		0...3
200	4000		11213
100	2000		11513–11813
3000	3000		31213
1500	1500		31513–31813
3000	3000	2322 663	03311; 02213
100	2000		1...1
550	2750		03911; 04711; 02713
100	2000		1...3
1500	1500		32213
100	2000	2322 664	0...1
100	2000		1...1
250	1250		0...3
100	2000		1...3

ELECTRICAL DATA

Table 3 Electrical data for **2322 66. 0/1/3...1;** max. voltage = 56 V (DC); see note 3. Preferred types in **bold.**

I_{nt}(1) MAX. at 25 °C (mA)	I_t(1) MIN. at 25 °C (mA)	I_{nt}(1) at 55 °C (mA)	I_t(1) at 10 °C (mA)	R_{25} (Ω)	V MAX. (DC) (V)	I MAX. at 25 °C (A)	I_{res} MAX. at V_{max} and 25 °C (mA)	DISSIP. FACTOR (mW/K)	CATALOGUE NUMBERS(2)
70	100	56	112	≈90	56	460	30	6	**2322 660 .5691**
90	125	68	136	≈60	56	600	30	6	**2322 660 .6891**
105	150	82	164	≈42	56	750	30	6	**2322 660 .8291**
130	180	100	200	≈32	56	950	35	7	**2322 661 .1011**
155	220	120	240	≈22	56	1300	35	7	**2322 661 .1211**
195	275	150	300	≈18	56	1600	40	7.5	**2322 661 .1511**
230	330	180	360	≈12.5	56	2200	45	8	**2322 662 .1811**
285	400	220	440	≈9	56	2900	50	9	**2322 662 .2211**
350	495	270	540	≈6.5	56	4000	50	9	**2322 662 .2711**
425	600	330	660	≈4.3	56	6300	60	10	2322 663 .3311
505	710	390	780	≈3.8	56	7300	70	12	2322 663 .3911
605	808	470	940	≈2.6	56	12000	70	12	2322 663 .4711
725	1020	560	1120	≈2.2	56	14000	100	16	2322 664 .5611
878	1240	680	1360	≈1.6	56	18000	100	16	2322 664 .6811

Notes

1. For leadless types the values given for I_{nt} and I_t are only valid for thermistors mounted in accordance with *"IEC 738"*. Thermistor dissipation depends on mounting and can slightly affect the typical values.
2. For leadless types replace the dot in the catalogue numbers by 0, for types with leads replace it by 1, and for reel packaging (for ∅D < 12.5 mm) replace it by 3.
3. The thermistors are clamped at the seating plane.

Thermistors for overload protection PTC 56 V and 265 V (T_S = 120 °C)

2322 66. 0/1/3.... series

Table 4 Electrical data for **2322 66. 0/1/3...3**; max. voltage = 265 V (RMS); see note 3. Preferred types in **bold**.

I_{nt}(1) MAX. at 25 °C (mA)	I_t(1) MIN. at 25 °C (mA)	I_{nt}(1) at 55 °C (mA)	I_t(1) at 10 °C (mA)	R_{25} (Ω)	V MAX. (RMS) (V)	I MAX. at 25 °C (A)	I_{res} MAX. at V_{max} and 25 °C (mA)	DISSIP. FACTOR (mW/K)	CATALOGUE NUMBERS(2)
15	22	12	24	≈1900	265	110	5	6	**2322 660 .1293**
20	27	15	30	≈1200	265	135	5	6	**2322 660 .1593**
25	33	18	36	≈850	265	165	5	6	**2322 660 .1893**
30	40	22	44	≈560	265	200	6	6	**2322 660 .2293**
35	50	27	54	≈380	265	250	6	6	**2322 660 .2793**
45	60	33	66	≈280	265	290	7	7	**2322 661 .3393**
50	70	39	78	≈200	265	350	7	7	**2322 661 .3993**
60	85	47	94	≈140	265	420	7	7	**2322 661 .4793**
70	100	56	112	≈100	265	500	8	7	**2322 661 .5693**
90	125	68	136	≈72	265	600	8	8	**2322 661 .6893**
105	150	82	164	≈50	265	730	9	8	**2322 661 .8293**
130	185	100	200	≈33	265	900	9	8	**2322 661 .1013**
155	220	120	240	≈26	265	1100	12	8.5	**2322 662 .1213**
195	275	150	300	≈20	265	1300	12	9.5	**2322 662 .1513**
230	325	180	360	≈14	265	1700	14	9.5	**2322 662 .1813**
285	400	220	440	≈10	265	2100	16	10	2322 663 .2213
350	495	270	540	≈8	265	2500	19	12	2322 663 .2713
425	600	330	660	≈7	265	3000	25	16	2322 664 .3313
505	715	390	780	≈5	265	3600	25	16	2322 664 .3913
605	860	470	940	≈3.5	265	4300	25	16	2322 664 .4713

Notes

1. For leadless types the values given for I_{nt} and I_t are only valid for thermistors mounted in accordance with *"IEC 738"*. Thermistor dissipation depends on mounting and can slightly affect the typical values.
2. For leadless types replace the dot in the catalogue numbers by 0, for types with leads replace it by 1, and for reel packaging (for ∅D < 12.5 mm) replace it by 3.
3. The thermistors are clamped at the seating plane.

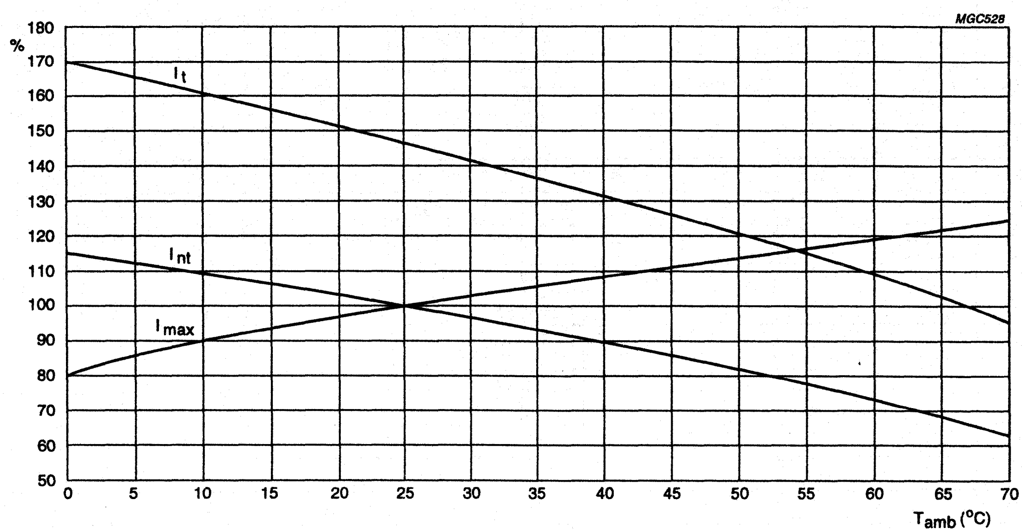
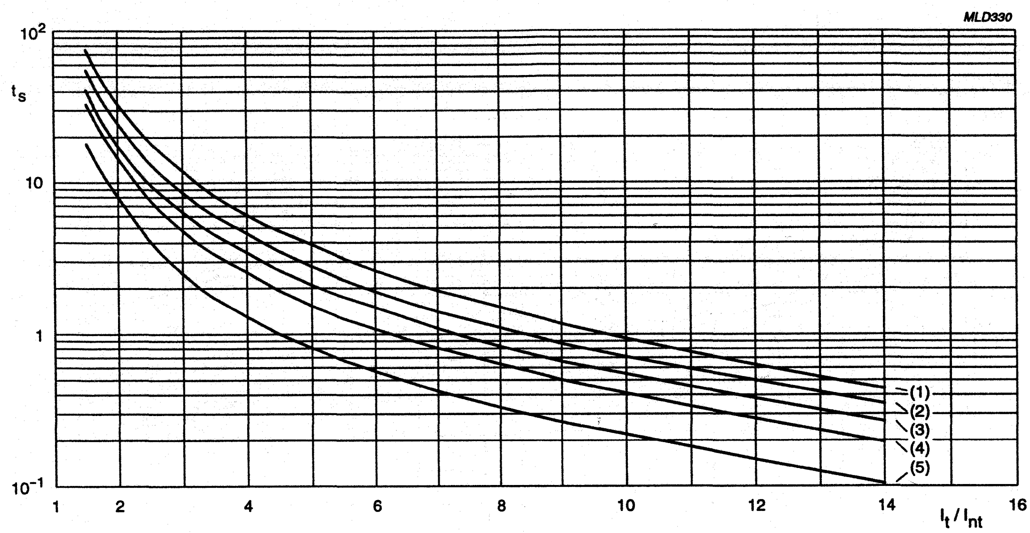
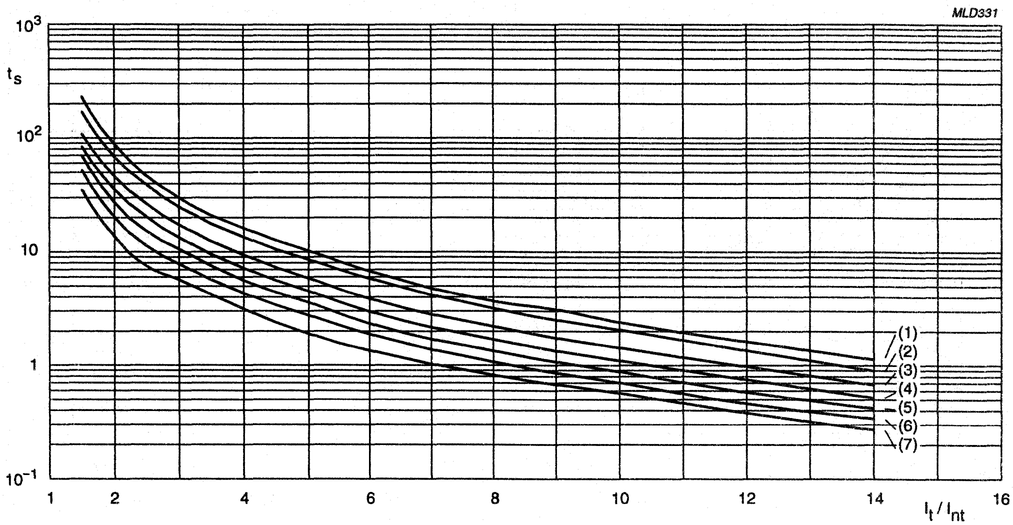


Fig.6 Current deviation as a function of the ambient temperature.



Curve 1: ∅D = 12.0 mm.
Curve 2: ∅D = 10.0 mm.
Curve 3: ∅D = 8.0 mm.
Curve 4: ∅D = 6.5 mm.
Curve 5: ∅D = 4.5 mm.
Measured in accordance with *"IEC 738"*.

Fig.7 Typical trip time as a function of trip current ratio for 2322 66. 0/1/3...1.



Curve 1: ØD = 20.0 mm.
Curve 2: ØD = 16.0 mm.
Curve 3: ØD = 12.0 mm.
Curve 4: ØD = 10.0 mm.
Curve 5: ØD = 8.0 mm.
Curve 6: ØD = 6.5 mm.
Curve 7: ØD = 4.5 mm.
Measured in accordance with *"IEC 738"*.

Fig.8 Typical trip time as a function of trip current ratio for 2322 66. 0/1/3...3 and 2322 66. 0/1/3...1 (ØD ≥ 12 mm).

Trip-time or switching time (t_s)

To check the trip-time for a specific PTC, refer to Table 3 or 4 for the value I_{nt}. Divide the overload or trip-current by this I_{nt} and you realize the factor I_t/I_{nt}. This rule is valid for any ambient temperature between 0 and 70 °C. Adapt the correct non-trip current with the appropriate curve in Fig.6. Figure 7 shows the relationship between the I_t/I_{nt} factor and the switching time as a function of the PTC diameter.

EXAMPLE

What will be the trip-time at I_{ol} = 3 A and T_{amb} = 10 °C of a thermistor type 2322 662 12711; 6.5 Ω; ØD = 12 mm:

I_{nt} from Table 3: 350 mA at 25 °C

I_{nt}: 350 × 1.08 = 378 mA (10 °C).

Overload current = 3 A; factor: $3/0.378$ = 7.94. In Fig.7 at the 12 mm line and I_t/I_{nt} = 7.94, the typical trip time is 1.6 s.

TESTS AND REQUIREMENTS

Clause numbers of tests and performance requirements refer to the *"CECC draft secretariat 2371 (January 1989)"*. AQLs are selected from *"IEC 410"*. Tables with requirements for lot by lot and periodic tests. In these tables:
D = Destructive
ND = Non-destructive.

Acceptable qualty level

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
Group A inspection (lot by lot)				
SUB-GROUP A1		ND		
4.3.1	visual examination			no defect likely to impair function
4.3.2	marking			
4.3.3	dimensions (gauging)			as specified
SUB-GROUP A2		ND		
4.4	zero power resistance		temperature: 25 °C	as specified
4.21	tripping current		measured at 25 °C	as specified
4.22	non-tripping current		measured at 25 °C	as specified
4.23	residual current at V_{max}		measured at 25 °C	as specified
Group B inspection (lot by lot)				
SUB-GROUP B1		D		
4.13.1	soldering, solderability		solder bath method: 235 ±5 °C	the leads shall be evenly tinned

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
Group C inspection (periodic)				
SUB-GROUP C1		D		
4.20.1	Endurance (cycling)		10 samples duration: 10 cycles temperature: 25 °C voltage: for 2322 66. 0/1/3....1, 56 V (DC) for 2322 66. 0/1/3....3, 265 V (RMS) I_{max}: see Tables 3, 4 and Fig.6 cycle: 1 minute on and 9 minutes off visual examination zero power resistance at 25 °C	 as in 4.20.1.8 ΔR/R: ≤±10%
			10 samples duration: 10 cycles temperature: 0 °C voltage: for 2322 66. 0/1/3....1, 56 V (DC) for 2322 66. 0/1/3....3, 265 V (RMS) I_{max}: see Tables 3, 4 and Fig.6 cycle: 1 minute on and 9 minutes off visual examination zero power resistance at 25 °C	 as in 4.20.1.8 ΔR/R: ≤±10%

Thermistors for overload protection PTC 56 V and 265 V (T_S = 120 °C)

2322 66. 0/1/3.... series

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
SUB-GROUP C2		D		
4.12	robustness of terminations		half of the sample visual examination zero power resistance at 25 °C	 as in 4.12.4; note 1 ΔR/R: ≤±10%
4.13.2	resistance to soldering heat		test Tb of *"IEC 68-2-20A"* visual examination zero power resistance at 25 °C	 as in 4.13.2.3 ΔR/R: ≤±10%
4.14	rapid change of temperature		other half of the sample T_A: lower category temperature: −25 °C T_B: upper category temperature: +125 °C number of cycles: 5 visual examination zero power resistance at 25 °C	 as in 4.14.4 ΔR/R: ≤±10%
4.18 Climatic sequence			all the sample	as in 4.18.7.1
SUB-GROUP C3		D		
4.20.3	endurance at maximum rated temperature		duration: for 2322 66. 0/1/3....1 series, 24 hours at 70 °C and 56 V (DC) for 2322 66. 0/1/3....3 series, 24 hours at 70 °C and 265 V (RMS) examination at 24 hours visual examination zero power resistance at 25 °C	 as in 4.20.3.10 ΔR/R: ≤±10%
SUB-GROUP C4		D		
4.19	damp heat, steady state		visual examination zero power resistance at 25 °C	as in 4.19.5 ΔR/R: ≤±10%

Note

1. Leads should neither come loose or break.

Thermistors for overload protection PTC 30, 145 and 265 V (T_s = 140 °C)

2322 66. 4/5/6.... series

FEATURES

- Different voltages to be chosen in function of the application
- Available in three mechanical versions
  - 2322 66. 4.... naked discs
  - 2322 66. 5.... leaded and coated
  - 2322 66. 6.... taped, on reel (to diameter 12.5 mm)
- Wide range of trip and non-trip currents: from 17 mA up to 3 A for the trip current
- Wide range of resistance: from 0.3 Ω up to 3 kΩ
- Small ratio between trip and non-trip currents (I_t/I_{nt} = 1.5 at 25 °C)
- High maximum inrush current
- Excellent long term behaviour, also in humidity
- Leaded parts withstand mechanical stresses and vibration
- Clear marking: the grey lacquered thermistors with a diameter of 8.5 to 12.5 mm are marked with PH, R_{25} value (example 4R6) on one side and I_{nt}, V_{max} on the other
- UL approved PTCs are guaranteed to withstand severe test programmes including:
  - long-life cycle tests (over 5000 trip cycles)
  - long-life storage tests (3000 hours at 250 °C)
  - cycle tests at low ambient temperatures (–40 °C or 0 °C)
  - damp-heat and water immersion tests
  - overvoltage tests at up to 200% of rated voltage.

APPLICATIONS

- Telecommunications
- Automotive systems
- Industrial electronics
- Consumer electronics
- Electronic data processing.

DESCRIPTION

These directly heated thermistors have a positive temperature coefficient and are primarily intended for overload protection. They consist of a naked disc or with two tinned brass leads and coated.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Switch temperature; note 1	140	°C
Maximum voltage; note 2:		
2322 66. 4/5/6...1	30 to 60	V (DC)
2322 66. 4/5/6...2	145	V (RMS)
2322 66. 4/5/6...3	265	V (RMS)
Temperature range:		
2322 66. 4/5/6...1	–40 to 85	°C
2322 66. 4/5/6...2	0 to 70	°C
2322 66. 4/5/6...3	0 to 70	°C
Climatic category	40/125/56	

Notes

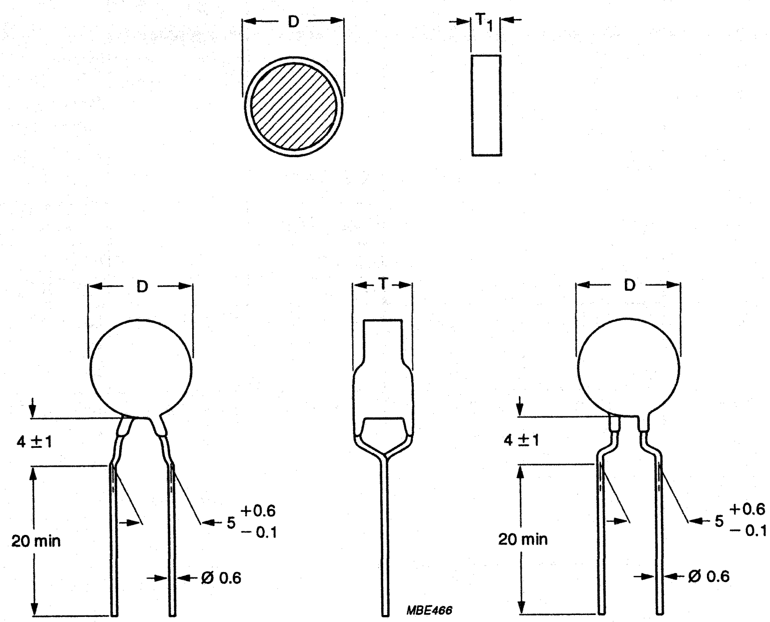
1. 2322 660 4/5/6 ...3 types, have a 120 °C switch temperature.
2. Rated voltages are respectively:

   24 to 48 V (DC)

   120 V (RMS)

   230 V (RMS).

MECHANICAL DATA



Dimensions in mm.
For D see Table 1; for T_1 and T see Table 2.
Either lead configuration can be delivered.

Fig.1 Component outline for 2322 66. 4/5...1/2/3.

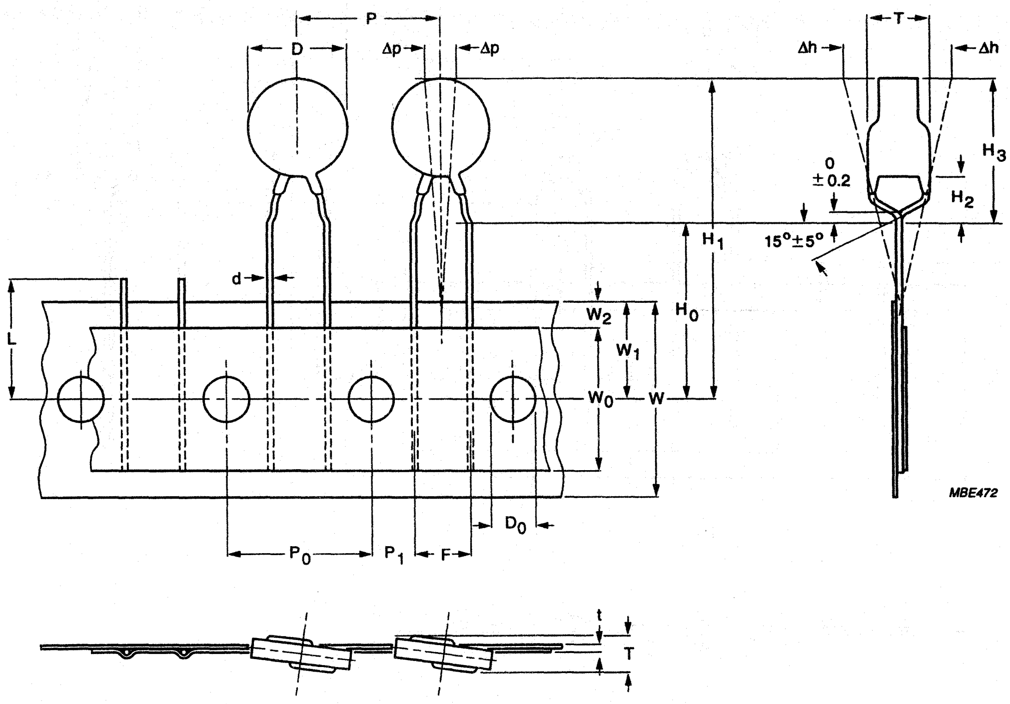
Table 1 Device and tape dimensions, packaging and catalogue numbers

D MAX. (mm)	H_1 MAX. (mm)	H_3 MAX. (mm)	PACKAGING			CATALOGUE NUMBERS 2322 ... .
			NAKED	LEADED BULK	LEADED TAPED	
5	26	9.5	Fig.1	Fig.1	Figs 2 and 3	660 .9491; 660 .1311; 660. 1811; 660 .2711; 660 .4792; 660 .6592; 660 .9392; 660 .1112; 660 .1312; 660 .1193; 660 .1593; 660 .1993; 660 .2893; 660 .3993; 660 .6393; 660 .7693; 660 .9593
7	28	11.5	Fig.1	Fig.1	Figs 2 and 3	661 .3211; 661 .4111; 661 .1712; 661 .2112; 661 .1113; 661 .1413
8.5	29.5	13.0	Fig.1	Fig.1	Figs 2 and 3	661 .4711; 661 .5411; 661 .2512; 661 .2712; 661 .1713; 661 .1913
10.5	31.5	15.0	Fig.1	Fig.1	Figs 2 and 3	662 .6111; 662 .7011; 662 .3212; 662 .3612; 662 .2113; 662 .2513
12.5	33.5	17.0	Fig.1	Fig.1	Figs 5 and 4	662 .8311; 662 .9211; 662 .4112; 662 .4512; 662 .2813; 662 .3213
16.5	–	–	Fig.1	Fig.1	–	663 .1121; 663 .1321; 663 .6012; 663 .7112; 663 .4013; 663 .4913
20.5	–	–	Fig.1	Fig.1	–	664 .1721; 664 .2021; 664 .8812; 664 .1022; 664 .5913; 664 .7013

Table 2 Thickness dimensions and catalogue numbers

T_1 MAX. (mm)	T MAX. (mm)	CATALOGUE NUMBERS 2322 ... .
1.5	4.0	66. 4/5...1
2.7	5.0	66. 4/5...2
3.0	5.5	66. 4/5...3

Thermistors on tape

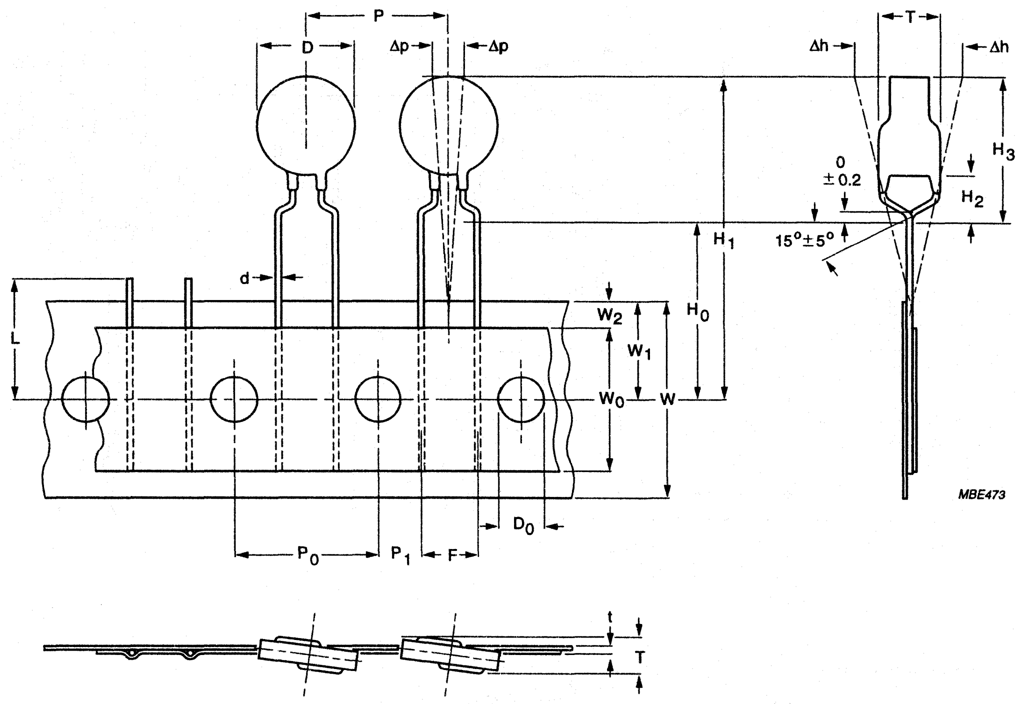


Dimensions in mm.

Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

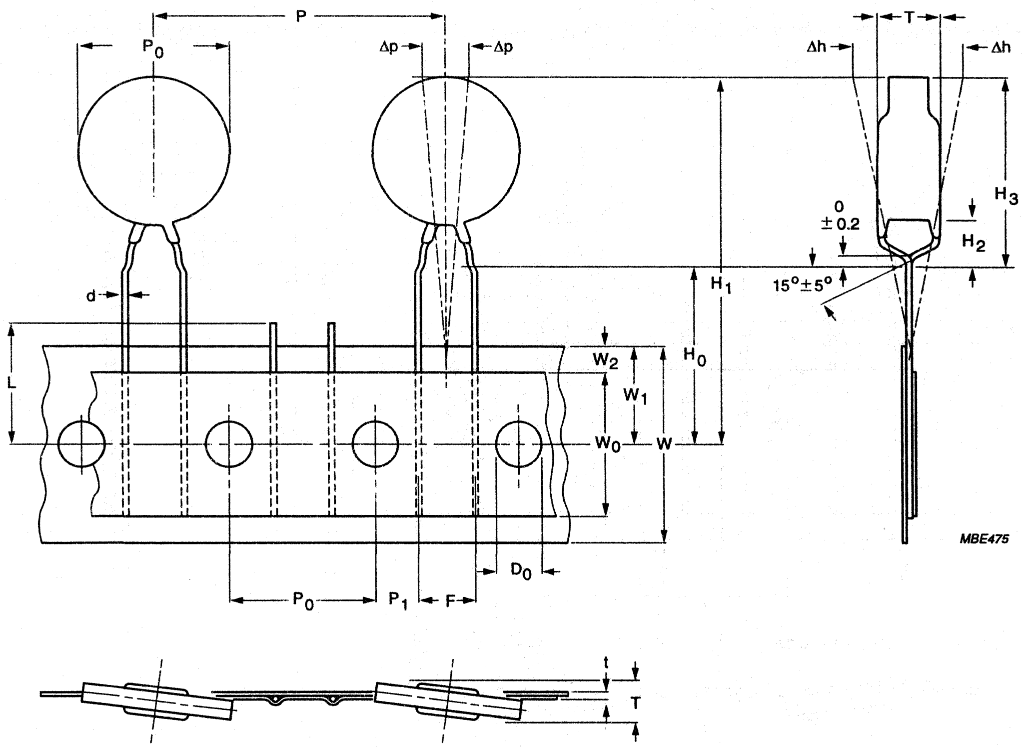
For dimensions, see Table 3.

Fig.2 Thermistors with ∅D < 12 mm on tape for 2322 66. 6...1/2/3.



Dimensions in mm.
Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.
For dimensions, see Table 3.

Fig.3 Thermistors with ∅D < 12 mm on tape for 2322 66. 6...1/2/3.



Dimensions in mm.

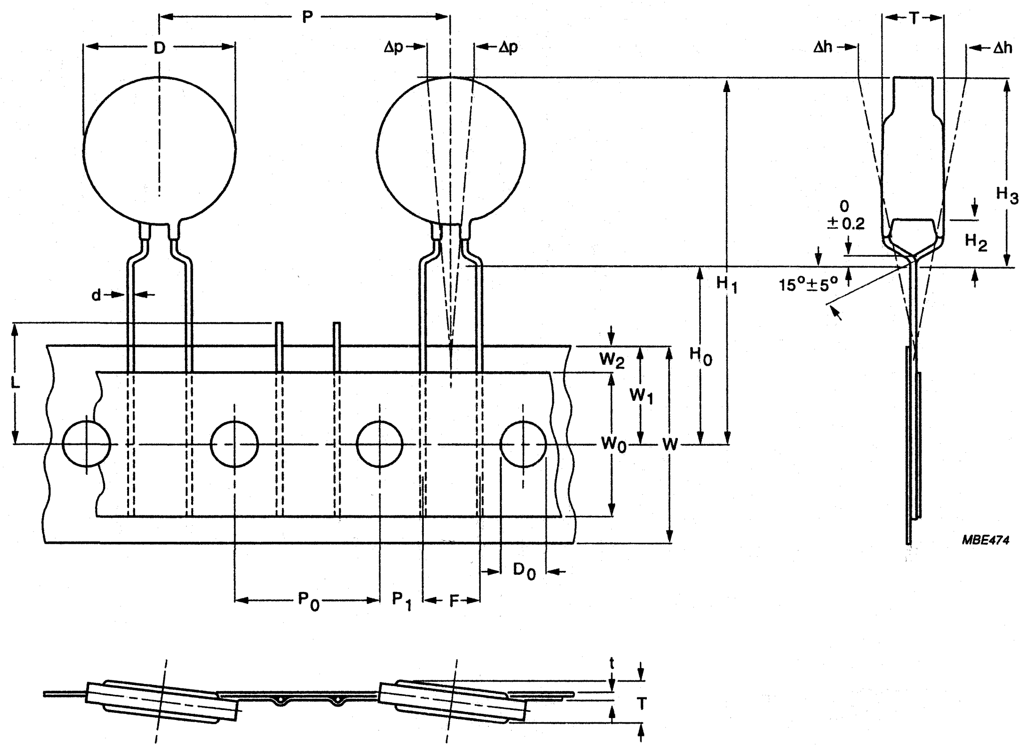
Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

For dimensions, see Table 3.

Fig.4 Thermistors ∅D > 12 mm on tape for 2322 66. 6...1/2/3.

Thermistors for overload protection PTC 30, 145 and 265 V (T_S = 140 °C)

2322 66. 4/5/6.... series



Dimensions in mm.

Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

For dimensions, see Table 3.

Fig.5 Thermistors ØD > 12 mm on tape for 2322 66. 6...1/2/3.

Characteristics concerning taped thermistors

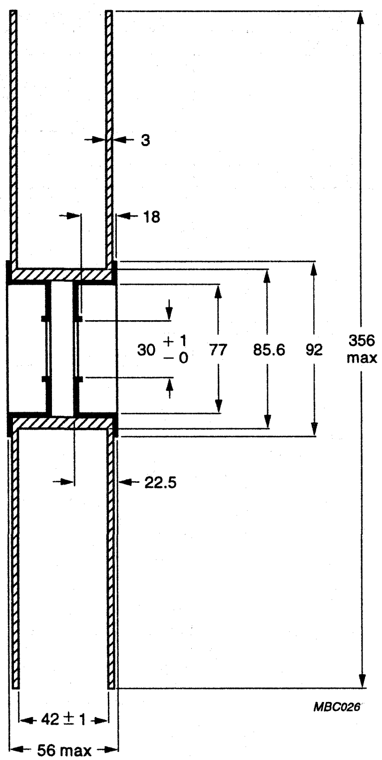
PARAMETER	VALUE
Minimum pull out force of the component	5 N
Minimum pull off force of adhesive tape	6 N
Minimum tearing force tape	15 N
Maximum pull off force tape-reel	5 N
Storage conditions	
Storage temperature range	–25 to 40 °C
Maximum relative humidity	80%

Tape and additional device information

Table 3 Tape and other device dimensions; see Figs 1, 2, 3, 4 and 5

SYMBOL	PARAMETER	DIMENSIONS (mm)	TOLERANCE	REMARKS
D	body diameter:			
	2322 66. 4/5/6...1	see Table 1		
	2322 66. 4/5/6...2	see Table 1		
	2322 66. 4/5/6...3	see Table 1		
T	total thickness:			
	2322 66. 4/5/6...1	see Table 2		
	2322 66. 4/5/6...2	see Table 2		
	2322 66. 4/5/6...3	see Table 2		
d	lead diameter	0.6	±10%	
P	pitch between thermistors:			
	see Figs 2 and 3	12.7	±1	
	see Figs 4 and 5	25.4	±2	
P_0	feed hole pitch	12.7	±0.3	cumulative pitch error ±1 mm/20 pitches
P_1	feed hole centre to lead centre	3.81	±0.7	guaranteed between component and tape
Δh	component alignment	0	±1.3	
F	lead to lead distance	5	+0.6 to −0.1	guaranteed between component and tape
Δh	component alignment	0	±2	
W	tape width	18	+1 to −0.5	
W_0	hold down tape width	≥12.3	–	
W_1	hole position	9	±0.5	
W_2	hold down tape position	≤3.0	–	
H_1	component height	see Table 1		
H_2	component body to seating plane	4	±1	
H_3	component top to seating plane	see Table 1		
H_0	lead-wire clinch height	16	±0.5	
D_0	feed hole diameter	4	±0.2	
t	total tape thickness	≤0.9	–	with cardboard tape 0.5 ±0.1 mm
L	length of snipped lead	≤11	–	

Reel information



Dimensions in mm.

Fig.6 Dimensions of the reel for 2322 66. 6...1/2/3.

PACKAGING INFORMATION

PACKAGING		CATALOGUE NUMBERS	
S.P.Q.	P.Q.	FIRST 7 DIGITS	LAST 5 DIGITS
5000	20000	2322 660	4...1
3000	12000		4...2 and 3
500	10000		5...1, 2 and 3
3000	3000		6...1, 2 and 3
5500	5500	2322 661	4...1
3000	3000		4...2
3000	3000		4...3
250	5000		5...1, 2 and 3
3000	3000		6...1, 2 and 3
5500	5500	2322 662	4...1
3000	3000		4...2 and 3
200	4000		56111–57011
3000	3000		66111–67011
100	2000		58311–59211
1500	1500		68311–69211
200	4000		53212–53612
3000	3000		63212–63612
100	2000		54112–54512
1500	1500		64112–64512
200	4000		52113–52513
3000	3000		62113–62513
100	2000		52813–53213
1500	1500		62813–63213
160	800	2322 663	4...1
1500	1500		4...2
1400	1400		4...3
100	2000		5...1, 2 and 3
160	800	2322 664	4...1
1500	1500		4...2
1400	1400		4...3
100	2000		5...1, 2 and 3

ELECTRICAL DATA

Table 4 Electrical data for **2322 66. 4/5/6...1**; max. voltage = 30 to 60 V (DC); see note 3. Preferred types in **bold**.

I_{nt}(1) MAX. at 25 °C (mA)	I_t(1) MIN. at 25 °C (mA)	R_{25} ±20% (Ω)	V MAX. (DC) (V)	I MAX. at 25 °C (A)	I_{res} MAX. at V_{max} and 25 °C (mA)	DISSIP. FACTOR (mW/K)	CATALOGUE NUMBERS(2)
94	145	50	60	0.8	22	6.9	**2322 660 .9491**
130	195	25	60	1.2	25	6.9	**2322 660 .1311**
180	270	13	30	1.7	45	6.9	**2322 660 .1811**
270	405	6	30	2.5	60	6.9	**2322 660 .2711**
320	480	5	30	3.5	62	7.8	**2322 661 .3211**
410	615	3	30	4.5	65	7.8	**2322 661 .4111**
470	705	2.5	30	5	70	8.8	**2322 661 .4711**
540	810	1.9	30	6	75	8.8	**2322 661 .5411**
610	915	1.7	30	7	80	9.9	**2322 662 .6111**
700	1050	1.3	30	8	90	9.9	**2322 662 .7011**
830	1245	1.1	30	10	100	11.5	**2322 662 .8311**
920	1380	0.9	30	11	105	11.5	**2322 662 .9211**
1170	1755	0.7	30	13.5	140	14.5	2322 663 .1121
1390	2085	0.5	30	16	170	14.5	2322 663 .1321
1770	2655	0.4	30	20	200	18.7	2322 664 .1721
2050	3075	50.3	30	23	220	18.7	2322 664 .2021

Notes

1. For leadless types the values given for I_{nt} and I_t are only valid for thermistors mounted in accordance with *"IEC 738"*. Thermistor dissipation depends on mounting and can slightly affect the typical values.
2. For leadless types replace the dot in the catalogue numbers by 4, for types with leads replace it by 5, and for reel packaging (for ∅D < 12.5 mm) replace it by 6.
3. The thermistors are clamped at the seating plane.

Thermistors for overload protection PTC 30, 145 and 265 V (T_S = 140 °C)

2322 66. 4/5/6.... series

Table 5 Electrical data for **2322 66. 4/5/6...2**; max. voltage = 145 V (RMS); see note 3. Preferred types in **bold**.

I_{nt}(1) MAX. at 25 °C (mA)	I_t(1) MIN. at 25 °C (mA)	R_{25} ±20% (Ω)	V MAX. (DC) (V)	I MAX. at 25 °C (A)	I_{res} MAX. at V_{max} and 25 °C (mA)	DISSIP. FACTOR (mW/K)	CATALOGUE NUMBERS(2)
47	70	240	145	200	9	7.3	2322 660 .4792
65	100	115	145	300	11	7.3	2322 660 .6592
93	140	55	145	450	13	7.3	2322 660 .9392
110	165	40	145	500	13	7.3	2322 660 .1112
130	195	28	145	600	13	7.3	2322 660 .1312
170	255	19	145	1000	15	8.3	2322 661 .1712
210	315	12	145	1400	15	8.3	2322 661 .2112
250	375	9.4	145	2000	16.5	9	2322 661 .2512
270	405	8	145	2200	16.5	9	2322 661 .2712
320	480	6.7	145	3000	19	10.5	2322 662 .3212
360	540	5.3	145	3500	19	10.5	2322 662 .3612
410	615	4.6	145	4500	22.5	11.7	2322 662 .4112
450	675	3.8	145	5000	22.5	11.7	2322 662 .4512
600	900	2.9	145	7200	28.5	15.5	2322 663 .6012
710	1065	2.1	145	8500	28.5	15.5	2322 663 .7112
880	1320	1.7	145	11000	37.5	19.8	2322 664 .8812
1000	1500	1.3	145	13000	37.5	19.8	2322 664 .1022

Notes

1. For leadless types the values given for I_{nt} and I_t are only valid for thermistors mounted in accordance with *"IEC 738"*. Thermistor dissipation depends on mounting and can slightly affect the typical values.
2. For leadless types replace the dot in the catalogue numbers by 4, for types with leads replace it by 5, and for reel packaging (for ØD < 12.5 mm) replace it by 6.
3. The thermistors are clamped at the seating plane.

Thermistors for overload protection PTC 30, 145 and 265 V (T_S = 140 °C)

2322 66. 4/5/6.... series

Table 6 Electrical data for **2322 66. 4/5/6...3**; max. voltage = 265 V (RMS); see note 3. Preferred types in **bold**.

I_{nt}(1) MAX. at 25 °C (mA)	I_t(1) MIN. at 25 °C (mA)	R_{25} ±20% (Ω)	V MAX. (DC) (V)	I MAX. at 25 °C (A)	I_{res} MAX. at V_{max} and 25 °C (mA)	DISSIP. FACTOR (mW/K)	CATALOGUE NUMBERS(2)
11	17	3000	265	80	6.5	7.3	**2322 660 .1193**
15	23	1900	265	110	6.5	7.3	**2322 660 .1593**
19	29	1200	265	140	6.5	7.3	**2322 660 .1993**
28	42	500	265	200	6.8	7.3	**2322 660 .2893**
39	59	260	265	300	6.8	7.3	**2322 660 .3993**
63	95	120	265	450	7	7.3	**2322 660 .6393**
76	115	85	265	550	7	7.3	**2322 660 .7693**
95	143	56	265	600	7	7.3	**2322 660 .9593**
110	165	48	265	650	7.5	8.3	**2322 661 .1113**
140	210	29	265	800	8	8.3	**2322 661 .1413**
170	255	22	265	900	9	9	**2322 661 .1713**
190	285	18	265	1000	9.5	9	**2322 661 .1913**
210	315	17	265	1300	10	10.5	**2322 662 .2113**
250	375	12	265	1500	11	10.5	**2322 662 .2513**
280	420	11	265	1800	12	11.7	**2322 662 .2813**
320	480	8.4	265	2200	13	11.7	**2322 662 .3213**
400	600	6.6	265	3000	15	15.5	2322 663 .4013
490	735	4.4	265	3500	16	15.5	2322 663 .4913
590	855	4	265	4500	19.5	19.8	2322 664 .5913
700	1050	2.8	265	5500	21	19.8	2322 664 .7013

Notes

1. For leadless types the values given for I_{nt} and I_t are only valid for thermistors mounted in accordance with *"IEC 738"*. Thermistor dissipation depends on mounting and can slightly affect the typical values.
2. For leadless types replace the dot in the catalogue numbers by 4, for types with leads replace it by 5, and for reel packaging (for ∅D < 12.5 mm) replace it by 6.
3. The thermistors are clamped at the seating plane.

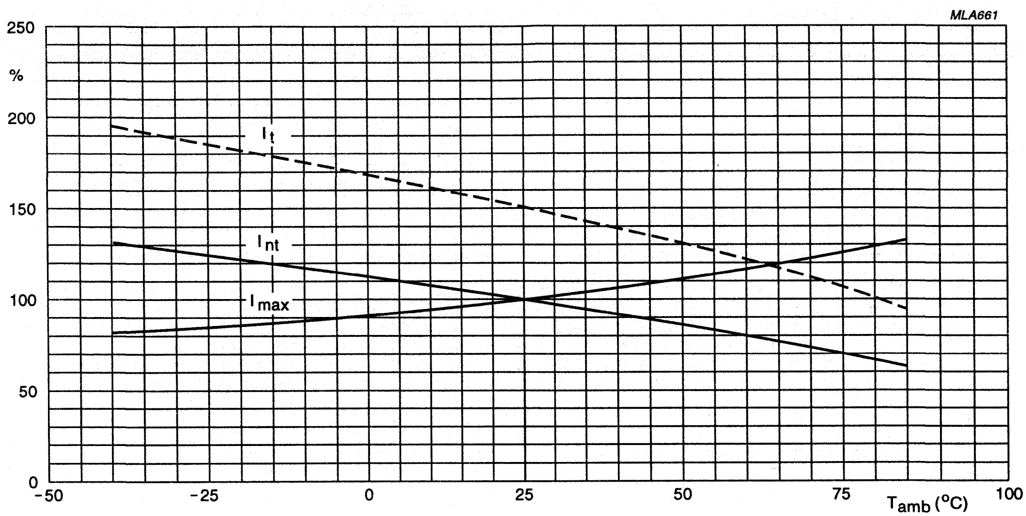
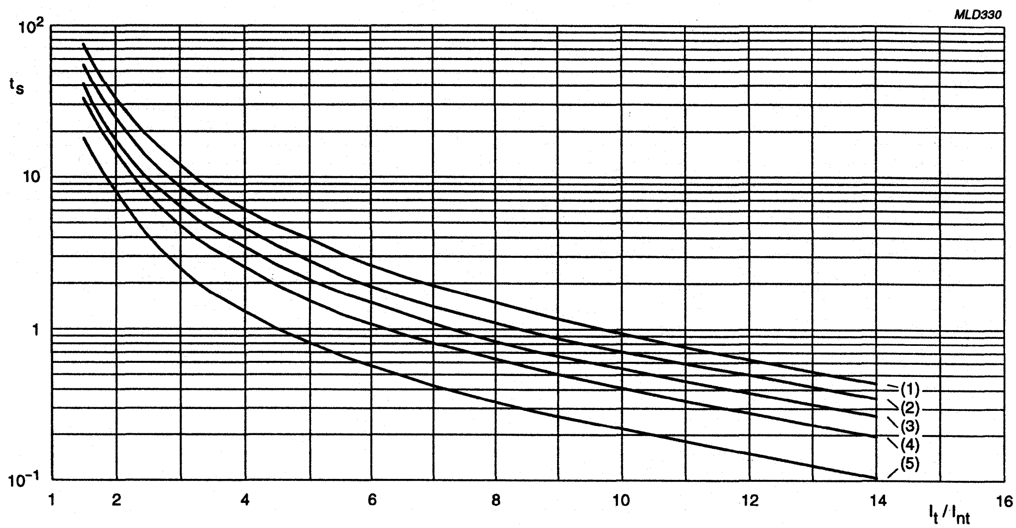
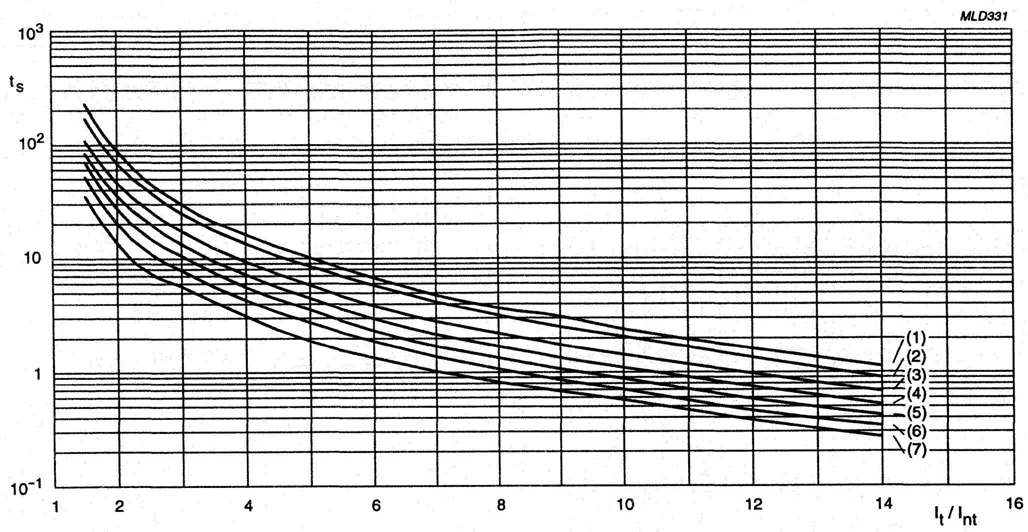


Fig.7 Current deviation as a function of the ambient temperature.



Curve 1: ØD = 12.0 mm.
Curve 2: ØD = 10.0 mm.
Curve 3: ØD = 8.0 mm.
Curve 4: ØD = 6.5 mm.
Curve 5: ØD = 4.5 mm.
Measured in accordance with *"IEC 738"*.

Fig.8 Typical trip time as a function of trip current ratio for 2322 66. 4/5/6...1.



Curve 1: ∅D = 20.0 mm.
Curve 2: ∅D = 16.0 mm.
Curve 3: ∅D = 12.0 mm.
Curve 4: ∅D = 10.0 mm.
Curve 5: ∅D = 8.0 mm.
Curve 6: ∅D = 6.5 mm.
Curve 7: ∅D = 4.5 mm.
Measured in accordance with *"IEC 738"*.

Fig.9 Typical trip time as a function of trip current ratio for 2322 66. 4/5/6...2/3.

Trip-time or switching time (t_s)

To check the trip-time for a specific PTC, refer to Table 4, 5 or 6 for the value I_{nt}. Divide the overload or trip-current by this I_{nt} and you realize the factor I_t/I_{nt}. This rule is valid for any ambient temperature between 0 and 70 °C. Adapt the correct non-trip current with the appropriate curve in Fig.7. Figures 8 and 9 show that the relationship between the I_t/I_{nt} factor and the switching time is a function of the PTC diameter.

EXAMPLE

What will be the trip-time at I_{ol} = 3 A and T_{amb} = 0 °C of a thermistor type 2322 661 54711; 2.5 Ω; ∅D = 8.0 mm:

I_{nt} from Table 4: 470 mA at 25 °C

I_{nt} : 470 × 1.12 = 526 mA (0 °C).

Overload current = 3 A; factor I_t/I_{nt}: $^3/_{0.470}$ = 5.70. In Fig.8 at the 8.0 mm line and I_t/I_{nt} = 5.70, the typical trip time is 1.7 s.

Typical R-T characteristics

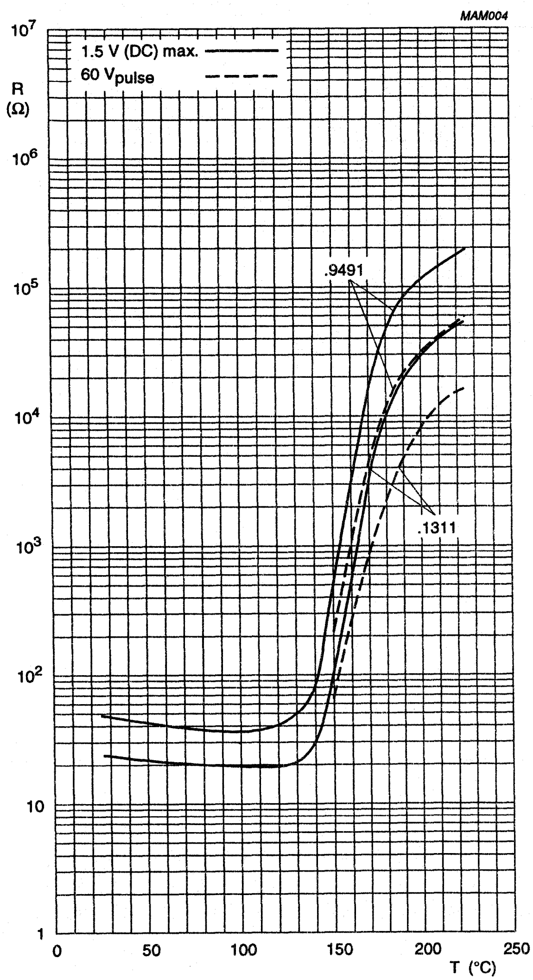


Fig.10 Typical resistance/temperature characteristic for 2322 660 .9491/.1311.

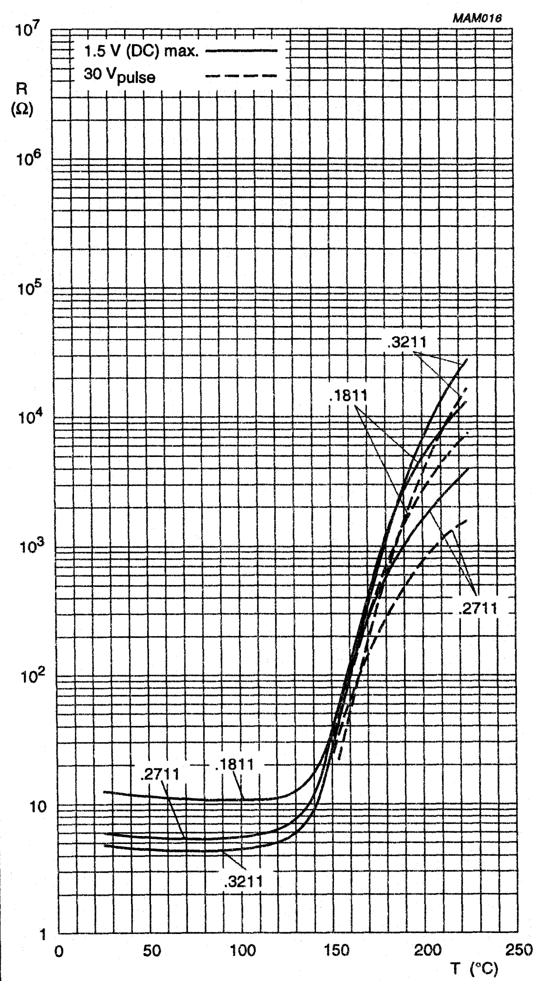


Fig.11 Typical resistance/temperature characteristic for 2322 660 .1811/.2711 and 661 .3211.

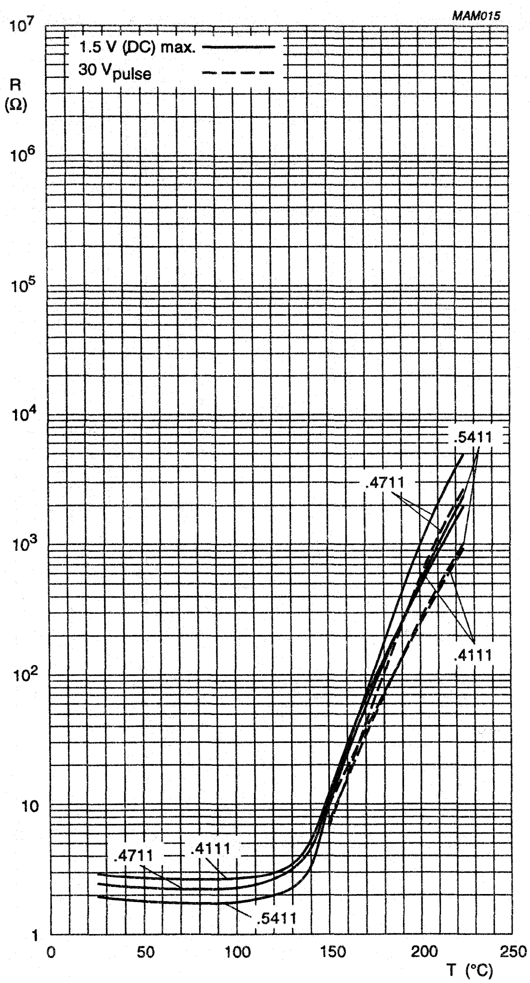


Fig.12 Typical resistance/temperature characteristic for 2322 661 .4111/.4711/.5411.

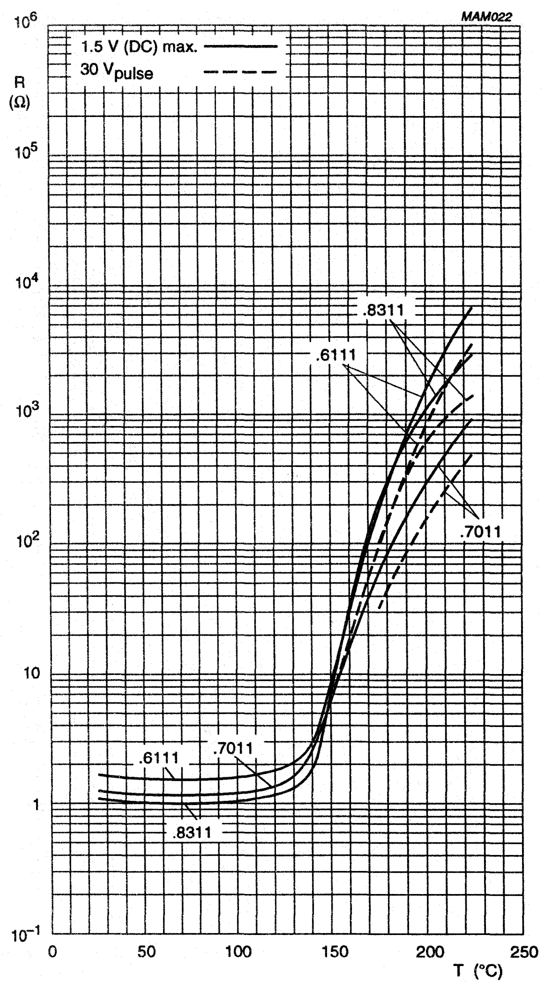


Fig.13 Typical resistance/temperature characteristic for 2322 662 .6111/.7011/.8311.

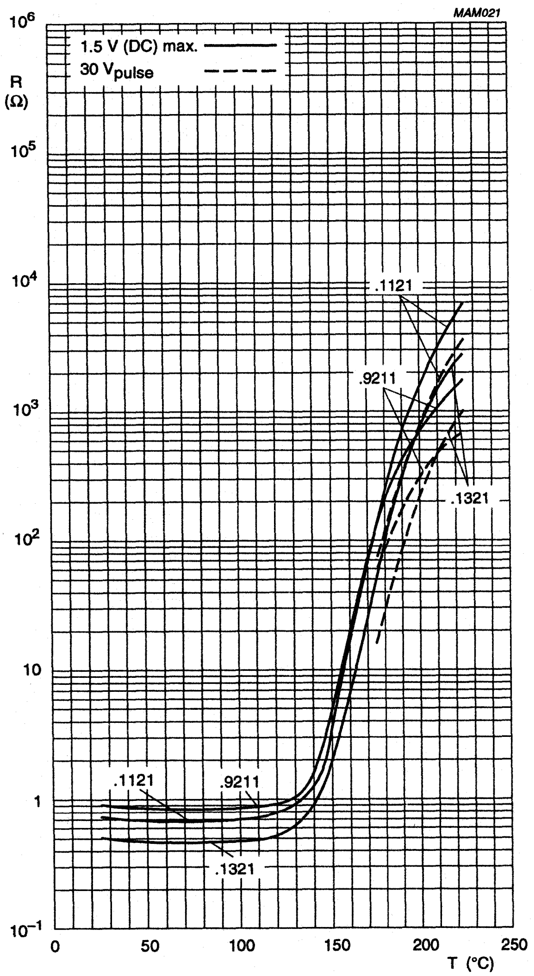


Fig.14 Typical resistance/temperature characteristic for 2322 662 .9211 and 663 .1121/.1321.

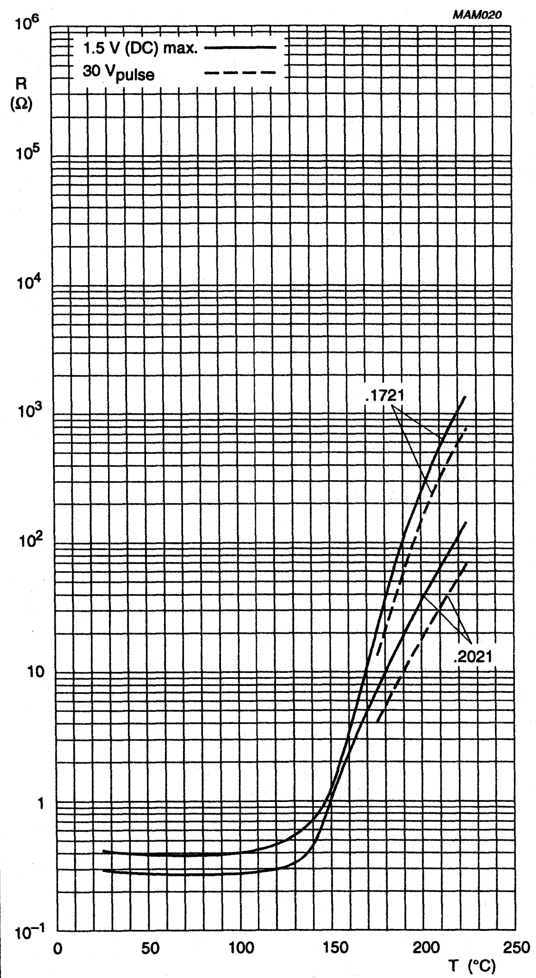


Fig.15 Typical resistance/temperature characteristic for 2322 664 .1721/.2021.

Thermistors for overload protection PTC 30, 145 and 265 V (T_s = 140 °C)

2322 66. 4/5/6.... series

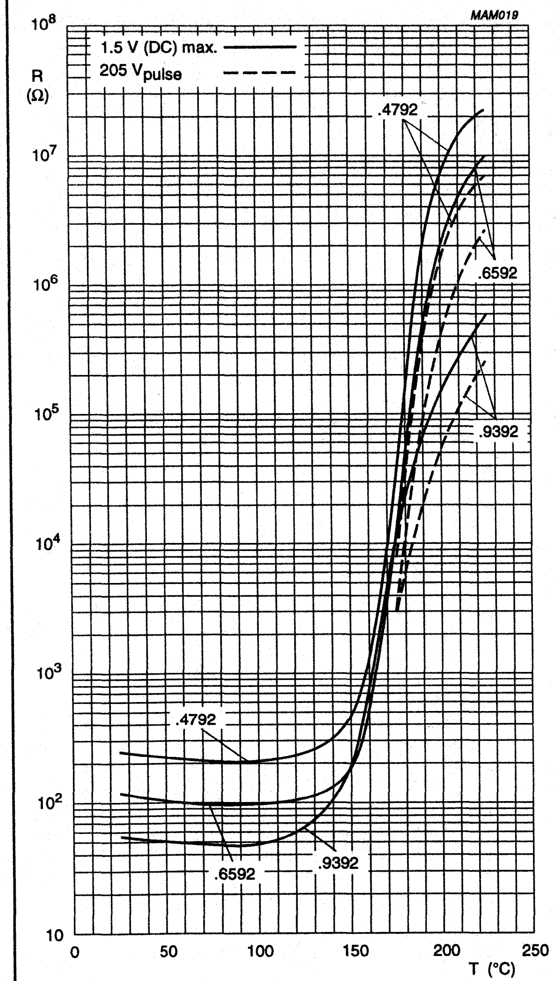


Fig.16 Typical resistance/temperature characteristic for 2322 660 .4792/.6592/.9392.

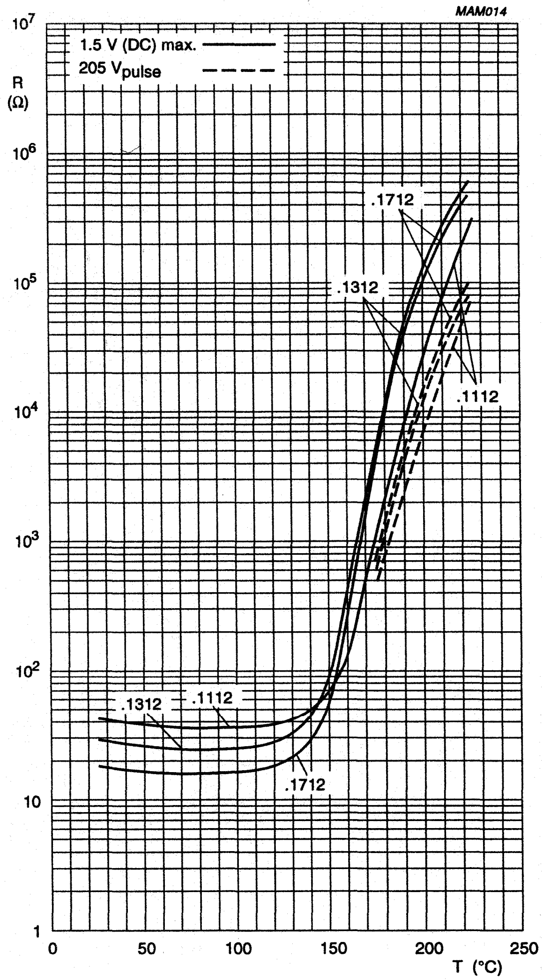


Fig.17 Typical resistance/temperature characteristic for 2322 660 .1112/.1312 and 661 .1712.

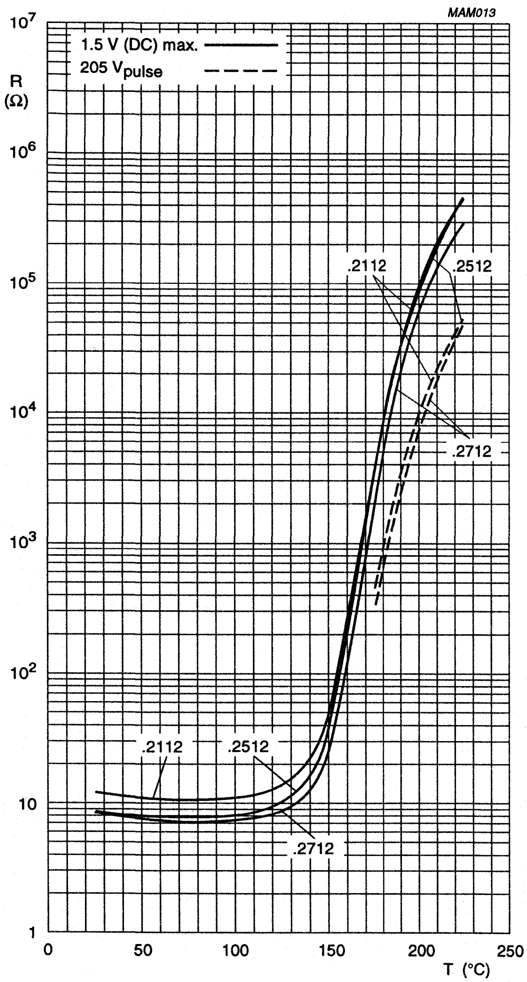


Fig.18 Typical resistance/temperature characteristic for 2322 661 .2112/.2512/.2712.

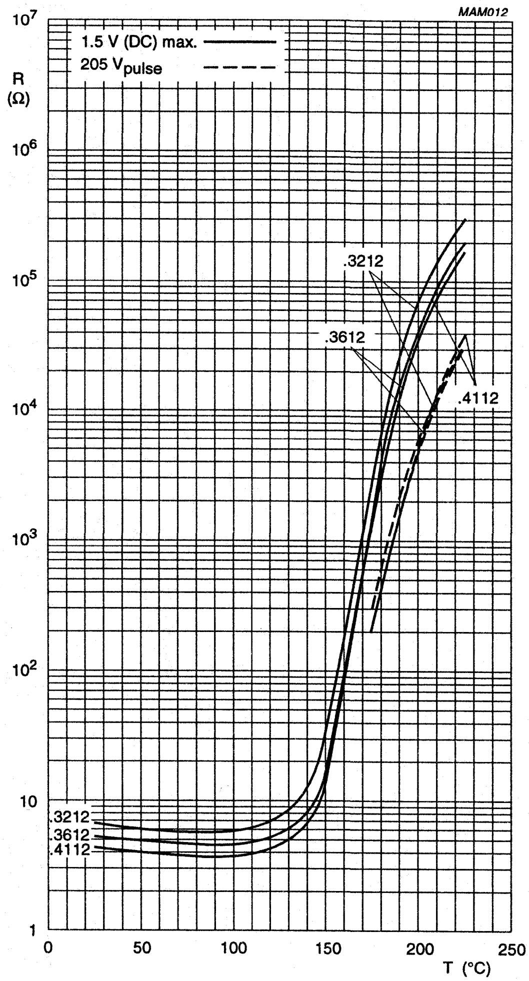


Fig.19 Typical resistance/temperature characteristic for 2322 662 .3212/.3612/.4112.

Thermistors for overload protection PTC 30, 145 and 265 V (T_S = 140 °C)

2322 66. 4/5/6.... series

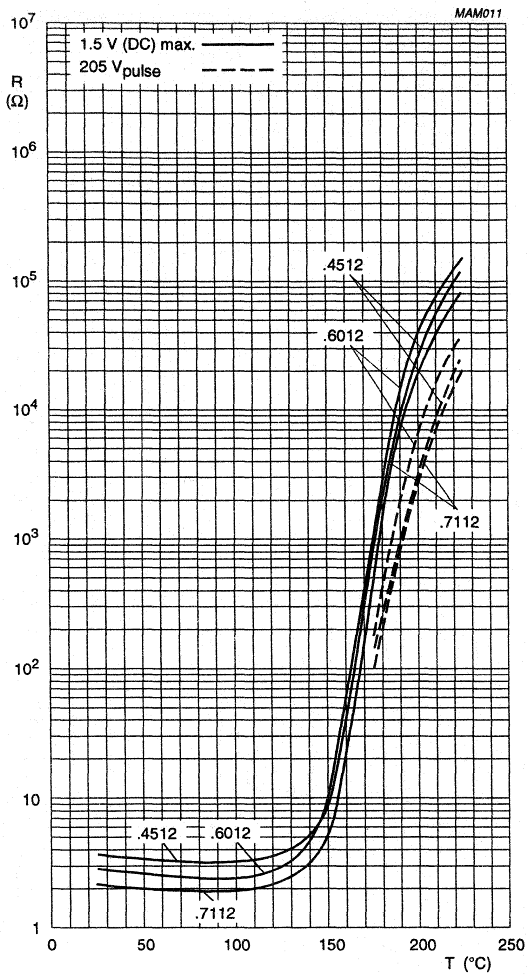


Fig.20 Typical resistance/temperature characteristic for 2322 662 .4512 and 663 .6012/.7112.

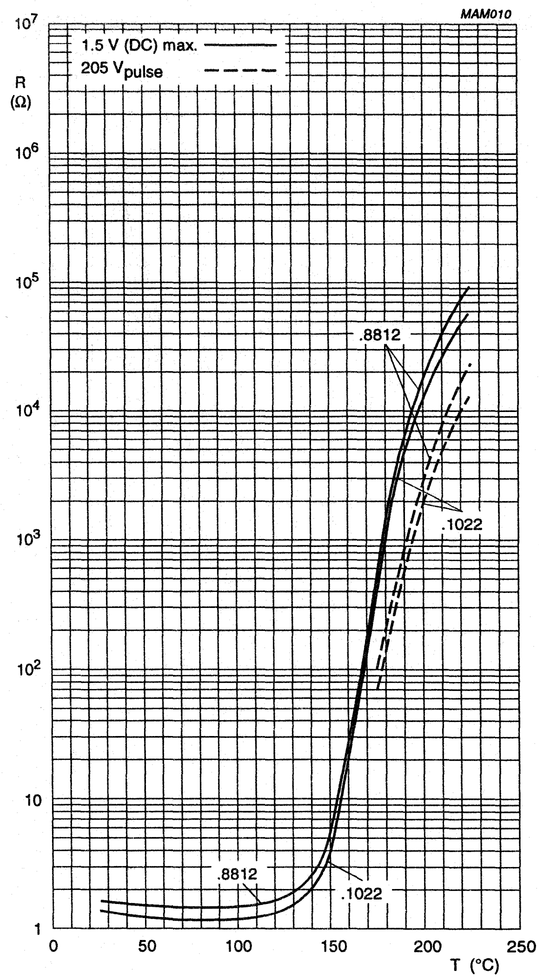


Fig.21 Typical resistance/temperature characteristic for 2322 664 .8812/.1022.

Thermistors for overload protection PTC 30, 145 and 265 V (T_s = 140 °C)

2322 66. 4/5/6.... series

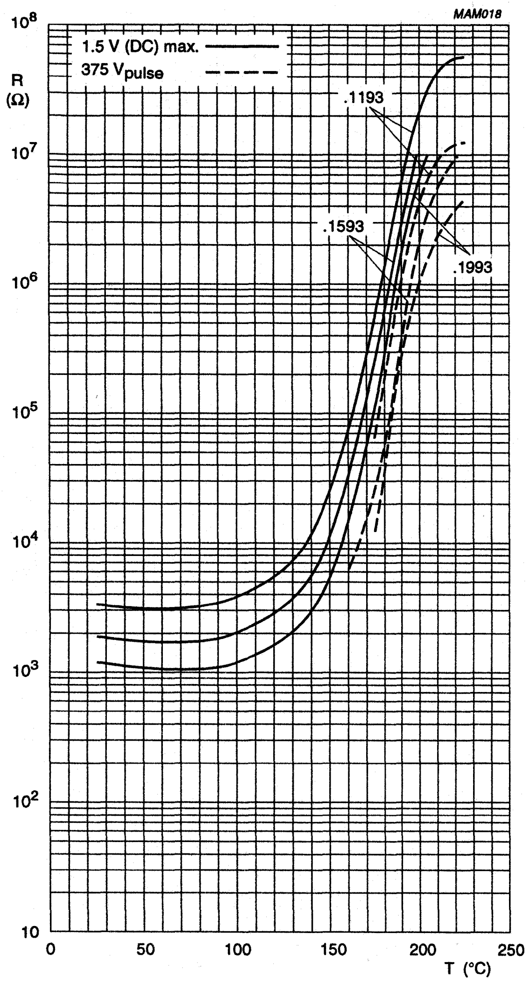


Fig.22 Typical resistance/temperature characteristic for 2322 660 .1193/.1593/.1993.

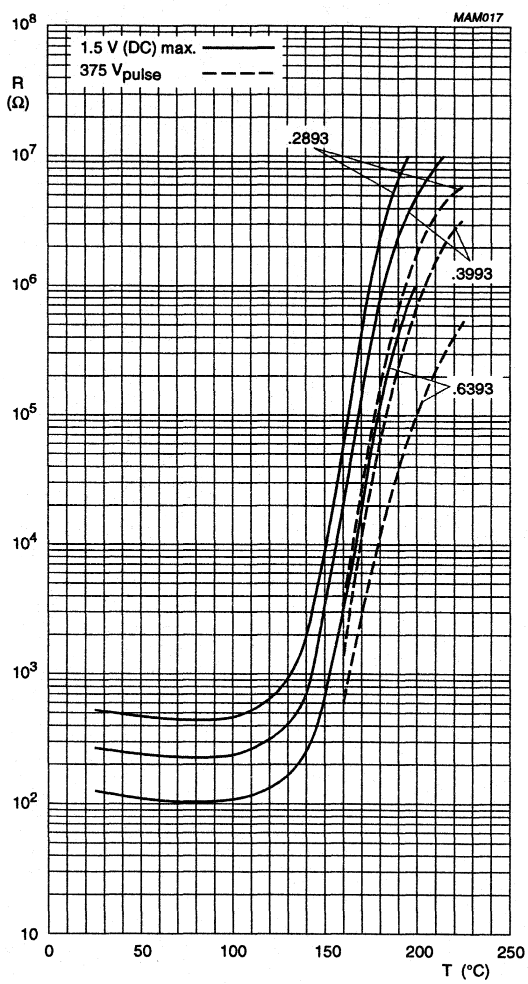


Fig.23 Typical resistance/temperature characteristic for 2322 660 .2893/.3993/.6393.

Thermistors for overload protection PTC 30, 145 and 265 V (T_s = 140 °C)

2322 66. 4/5/6.... series

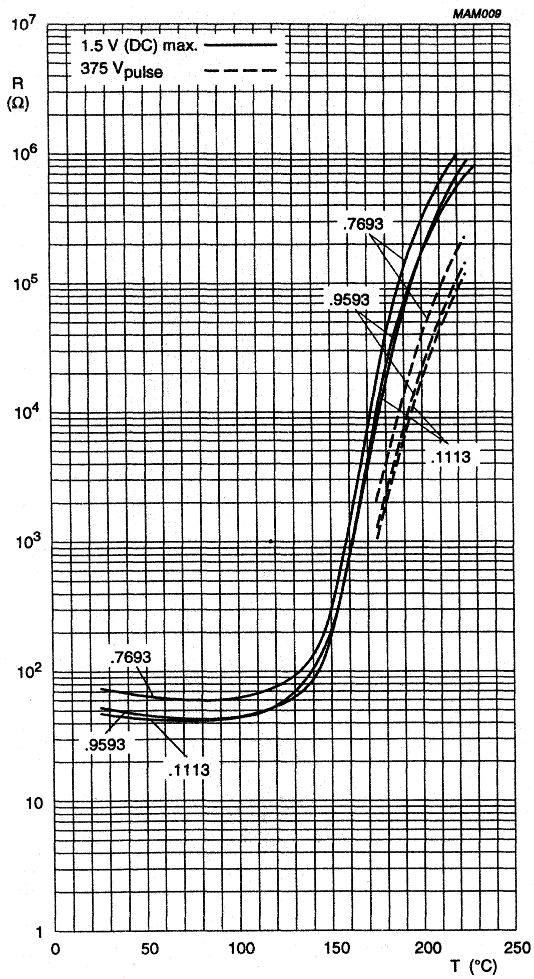


Fig.24 Typical resistance/temperature characteristic for 2322 660 .7693/.9593 and 661 .1113.

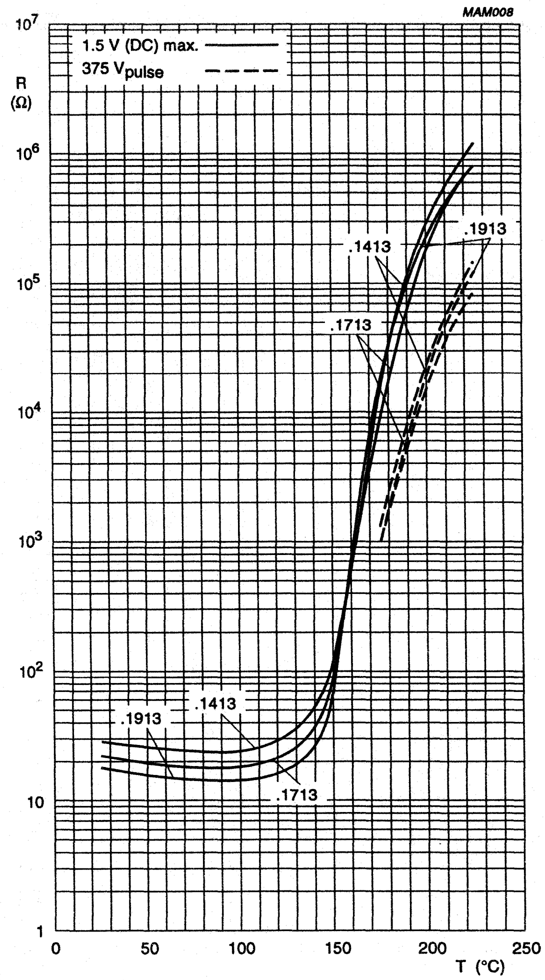


Fig.25 Typical resistance/temperature characteristic for 2322 661 .1413/.1713/.1913.

Thermistors for overload protection PTC 30, 145 and 265 V (T_S = 140 °C)

2322 66. 4/5/6.... series

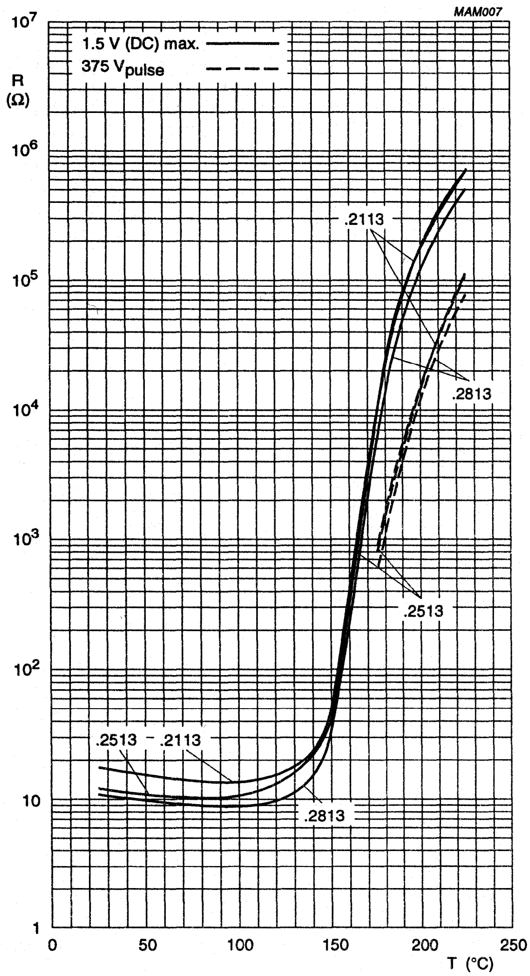


Fig.26 Typical resistance/temperature characteristic for 2322 662 .2113/.2513/.2813.

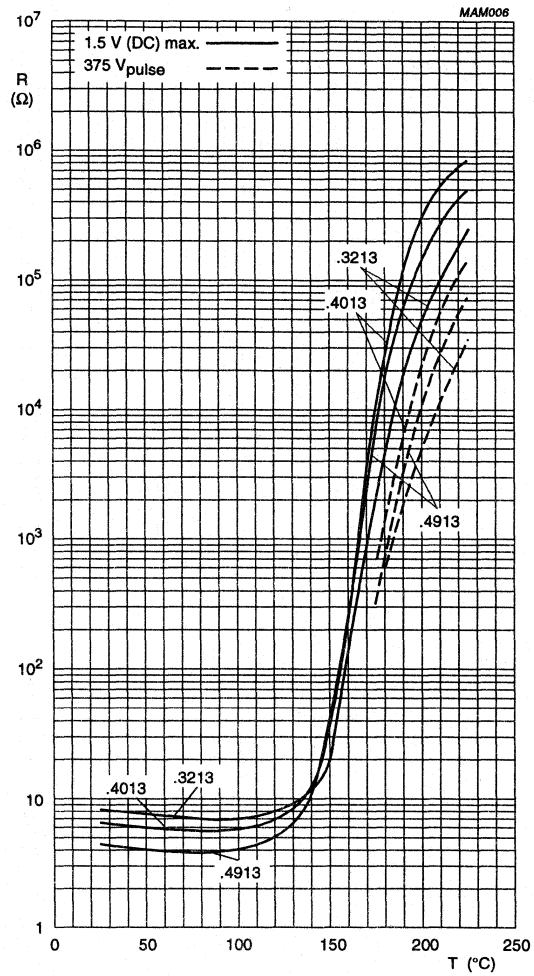


Fig.27 Typical resistance/temperature characteristic for 2322 662 .3213 and 663 .4013/.4913.

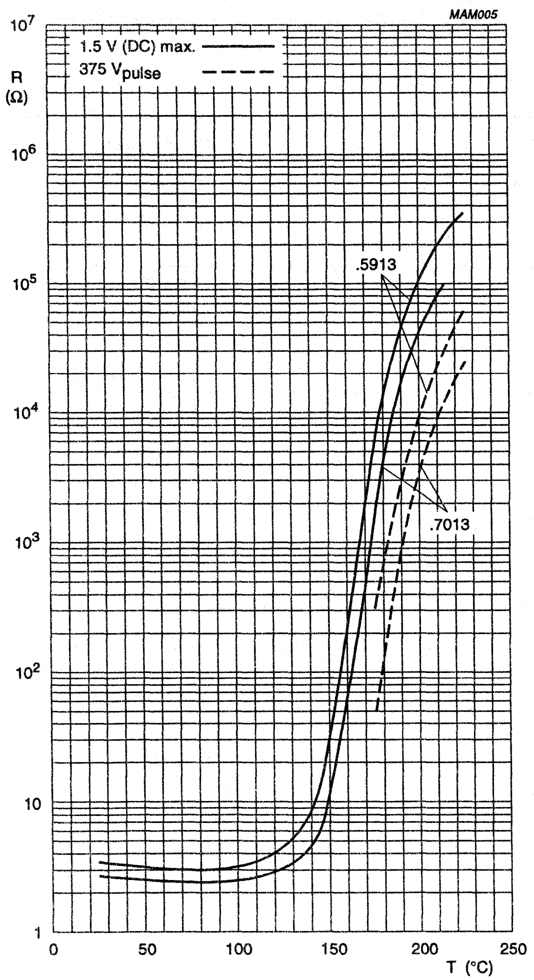


Fig.28 Typical resistance/temperature characteristic for 2322 664 .5913/.7013.

TESTS AND REQUIREMENTS

Clause numbers of tests and performance requirements refer to the *"CECC draft secretariat 2371 (January 1989)"*. AQLs are selected from *"IEC 410"*. Tables with requirements for lot by lot and periodic tests. In these tables:
D = Destructive
ND = Non-destructive.

Acceptable qualty level

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
Group A inspection (lot by lot)				
SUB-GROUP A1		ND		
4.3.1. 4.3.2. 4.3.3.	visual examination marking dimensions (gauging)			no defect likely to impair function as specified
SUB-GROUP A2		ND		
4.4. 4.21. 4.22. 4.23.	zero power resistance tripping current non-tripping current residual current at V_{max}		temperature: 25 °C measured at 25 °C measured at 25 °C measured at 25 °C	as specified as specified as specified as specified
Group B inspection (lot by lot)				
SUB-GROUP B1		D		
4.13.1.	soldering, solderability		solder bath method: 235 ±5 °C	the leads shall be evenly tinned

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
Group C inspection (periodic)				
SUB-GROUP C1		D		
4.20.1.	Endurance (cycling)		10 samples duration: 10 cycles temperature: 25 °C voltage: for 2322 66. 4/5/6....1, 30 to 60 V (DC) for 2322 66. 4/5/6....2, 145 V (RMS) for 2322 66. 4/5/6....3, 265 V (RMS) I_{max}: see Tables 4, 5, 6 and Fig.7 cycle: 1 minute on and 9 minutes off visual examination zero power resistance at 25 °C	 as in 4.20.1.8 ΔR/R: ≤±10%
			10 samples duration: 10 cycles temperature: for 2322 66. 4/5/6....1, −40 °C for 2322 66. 4/5/6....2 and 3, 0 °C voltage: for 2322 66. 4/5/6....1, 24 to 48 V (DC) for 2322 66. 4/5/6....2, 120 V (RMS) for 2322 66. 4/5/6....3, 230 V (RMS) I_{max}: see Tables 4, 5, 6 and Fig.7 cycle: 1 minute on and 9 minutes off visual examination zero power resistance at 25 °C	 as in 4.20.1.8 ΔR/R: ≤±10%

CLAUSE NUMBER	TEST	D OR ND	CONDITIONS	PERFORMANCE
SUB-GROUP C2		D		
4.12.	robustness of terminations		half of the sample visual examination zero power resistance at 25 °C	 as in 4.12.4; note 1 ΔR/R: ≤±10%
4.13.2.	resistance to soldering heat		test Tb of *"IEC 68-2-20A"* visual examination zero power resistance at 25 °C	 as in 4.13.2.3 ΔR/R: ≤±10%
4.14.	rapid change of temperature		other half of the sample T_A: lower category temperature: –40 °C T_B: upper category temperature: +125 °C number of cycles: 5 visual examination zero power resistance at 25 °C	 as in 4.14.4 ΔR/R: ≤±10%
4.18. Climatic sequence			all the sample	as in 4.18.7.1
SUB-GROUP C3		D		
4.20.3.	endurance at maximum rated temperature		duration: for 2322 66. 4/5/6....2 series, 24 hours at 70 °C and 145 V (RMS) for 2322 66. 4/5/6....3 series, 24 hours at 70 °C and 265 V (RMS) examination at 24 hours visual examination zero power resistance at 25 °C	 as in 4.20.3.10 ΔR/R: ≤±10%
SUB-GROUP C4		D		
4.19.	damp heat, steady state		visual examination zero power resistance at 25 °C	as in 4.19.5 ΔR/R: ≤±10%

Note

1. Leads should neither come loose or break.

PTC overload protection for telecommunication

GENERAL

Advanced developments in telephony equipment in recent years have radically altered the protection requirements for both exchange and subscriber equipment. The Philips Components range of Positive Temperature Coefficient (PTC) thermistors includes devices specially designed to provide overcurrent protection.

OVERCURRENT PROTECTION OF TELEPHONE LINES

The PTC thermistor must protect the telephone line circuit against overcurrent which may be caused by the following examples:

- Surges due to lightning strikes on or near to the line plant
- Short-term induction of alternating voltages from adjacent power lines or railway systems, usually caused when these lines or systems develop faults
- Direct contact between telephone lines and power lines.

To provide good protection under such conditions a PTC thermistor is connected in series with each line, usually as secondary protection; see Fig.1. However, even with primary line protection (usually a gas discharge tube), the PTC thermistor must fulfil severe requirements.

Surge pulses of up to 2 kV can occur and in order to withstand short-term power induction the PTC thermistor must withstand high voltages. If the line has primary protection a 220 V to 285 V PTC thermistor is adequate. Without primary protection, however, a 600 V PTC device is necessary. Philips Components manufacturers a range of PTC thermistors (see Tables 1, 3 and 4) covering both requirements.

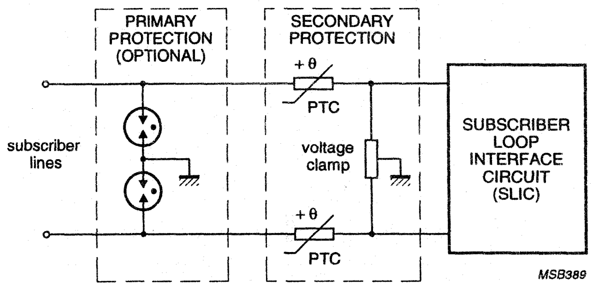


Fig.1 Typical telephone line equipment showing where PTC thermistors can be used for overcurrent protection.

In the case of direct contact between the telephone line and a power line, the PTC thermistor must withstand very high inrush power at normal mains voltage. Under such conditions, overloads of up to 5 A on a 600 V mains could occur for up to 1 hour. To handle this power, the resistance/temperature characteristic of the thermistor must have a very steep slope and the ceramic must be extremely homogeneous.

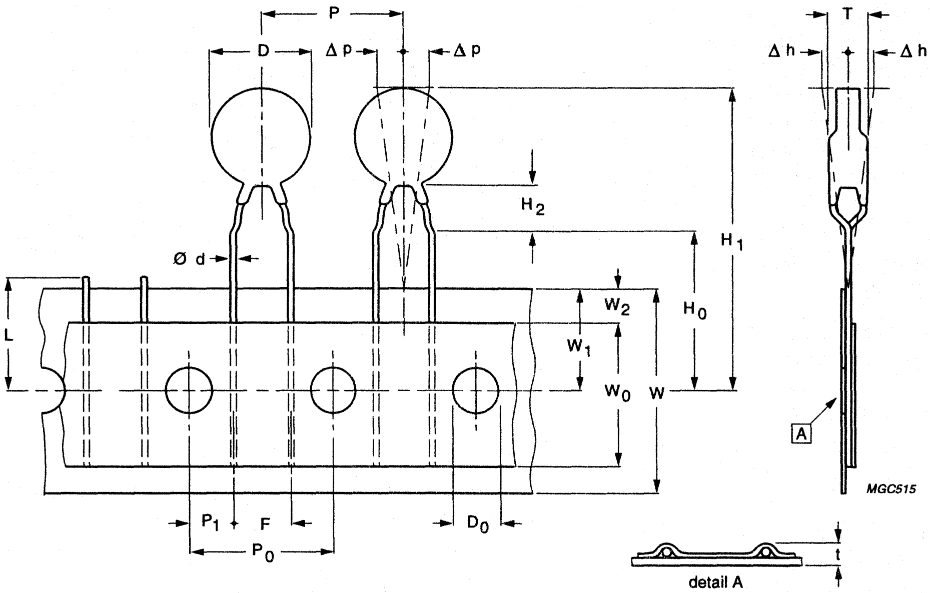
Philips Components has overcome these demands and the PTC thermistor 2322 661 93056 is available for the most demanding overcurrent protection. This 600 V device has a cold resistance (R_{25}) of 35 Ω. However, the latest Integrated Services Digital Network (ISDN) Telephone lines which carry high-frequency sound and vision, need lower line impedance.

Telecommunication designers are therefore demanding 600 V PTC thermistors with much lower R_{25} values, which places even greater demands on the manufacture of PTC thermistors. Again, Philips Components has overcome this demand with the 2322 662 93113 and 2322 663 93114 PTC thermistors which have R_{25} values 25 Ω and 10 Ω respectively, ideal for ISDN applications.

In a typical telephone line application, two PTC thermistors are used, one each for the up and down lines together with their series resistors. For good line balance it is important that the thermistor and resistor pairs are matched.

On request, Philips Components can supply pairs of PTC thermistors with R_{25} values matched to as close as 0.5 Ω.

MECHANICAL DATA



For dimensions see Tables 1 and 2.

Max. 0.5% of the total number of thermistors per reel may be missing, but no more than 3 consecutive positions may be vacant.

Fig.2 Thermistors on tape.

Table 1 Specific physical dimensions and packaging for catalogue numbers as listed; see Fig.2

D NOM. (mm)	T MAX. (mm)	H_1 MAX. (mm)	H_2 (mm)	H_0 NOM. (mm)	PACKAGING	CATALOGUE NUMBER 2322 ... .
8.0 ±0.5	5	28.0	1.5 to 3.0	16 ±0.5	on tape	661 93048
6.4 ±0.3	4	30.0	1.5 to 3.0	18 ±0.5	on tape	661 93025
8.0 ±0.3	4	30.0	1.5 to 3.0	18 ±0.5	on tape	661 93043(1)
6.5 ±0.3	4.3	26.6	1.5 to 3.0	16 ±0.5	on tape	661 93046
≤11	4.5	32.2	4 ±1.0	16 ±0.5	on tape	662 93081
≤11	4.5	32.2	4 ±1.0	16 ±0.5	on tape	662 93074(1)
7.7 ±0.3	5	27.5	2.5 ±0.5	16 ±0.5	on tape	661 93056
≤10.5	5	29.1	2 ±0.5	16 ±0.5	on tape	662 93113

Note

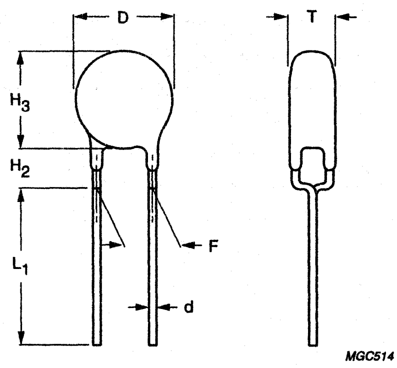
1. Insulated version is also available.

PTC overload protection for telecommunication

Table 2 Tape and other device dimensions; see Fig.2

SYMBOL	PARAMETER	DIMENSIONS (mm)	TOLERANCE
D	body diameter	see Tables 1 and 3	
T	total thickness	see Tables 1 and 3	
d	lead diameter	0.6	±10%
P	pitch between thermistors	12.7	±1
P_0	feed-hole pitch	12.7	±0.3
P_1	feed-hole centre to lead centre	3.81	±0.7
Δp	component alignment	0	±1.3
F	lead-to-lead distance	5	+0.6/−0.1
Δh	component alignment	0	±2
W	tape width	18	+1/−0.5
W_0	hold-down tape width	≥12.5	−
W_1	hole position	9	±0.5
W_2	hold-down tape position	≤3	−
H_0	lead-wire clinch height	see Tables 1 and 3	
H_1	component height	see Tables 1 and 3	
H_2	component bottom to seating plane	see Tables 1 and 3	
D_0	feed-hole diameter	4	±0.2
t	total tape thickness	≤0.9	−
L	length of snipped lead	≤11	−

PTC overload protection for telecommunication



For dimensions see Table 3.

Fig.3 Thermistors in bulk.

Table 3 Specific physical dimensions and packaging for catalogue numbers as listed; see Fig.3

D NOM. (mm)	T MAX. (mm)	F (mm)	L_1 MIN. (mm)	H_2 (mm)	H_3 MAX. (mm)	PACKAGING	CATALOGUE NUMBER 2322 ... .
6.2 ±1	5	5 +0.6/–0.1	–	1.5 to 3	–	leaded, bulk	661 93037
≤7	4	5 +0.6/–0.1	20.0	4 ±1.0	12.0	leaded, bulk	661 93099
13.0 ±0.6	6	5 +0.8/–0.2	20 ±4.0	4 ±1.0	–	leaded, bulk	663 93025(1)
7.7 ±0.3	5	5 +0.6/–0.1	20	4 ±1.0	13.0	leaded, bulk	661 93094
8.0 ±0.3	5	5 +0.6/–0.1	20	1.5 ±0.5	–	leaded, bulk	661 93078
≤12.5	5.5	5 +0.6/–0.1	20	4 ±1.0	–	leaded, bulk	662 93114

Note

1. Insulated version.

PTC overload protection for telecommunication

ELECTRICAL DATA

Table 4 Electrical data for catalogue numbers as listed

V MAX. (V)	NON-TRIP CURRENT		RESISTANCE		MATCHED PAIRS AVAILABLE	TRIP CURRENT		MAX. TRIP TIME		CATALOGUE NUMBER 2322 ... .
	I_{nt} (mA)	at T (°C)	R_{25} (Ω)	TOL (%)		I_t (mA)	at T (°C)	t_t (s)	at I_t (mA)	
220	70	70	25	±20	±1 Ω	200	25	0.15	3700	661 93048
245	60	70	70	+10/−15	no	–	–	60	220	661 93025
245	75	70	33	±20	±5%	150	10	1.2	1000	661 93037
245	70	70	25	±15	1 Ω	–	–	120	220	661 93043(1)
245	65	85	25	±20	2%	–	–	3.40	650	661 93046
245	140	55	16	±20	no	–	–	0.08	10000	662 93081
245	140	55	10	±20	no	–	–	0.08	10000	662 93074(1)
250	110	40	17.5	±15	no	220	25	1.10	1000	661 93099
250	100	70	10	±20	no	450	0	0.30	8000	663 93025(2)
265	150	25	12.5	±20	no	250	25	3	1000	661 93094
285	135	95	8	±25	0.5 Ω	–	–	180.00	500	661 93078
600	70	70	35	±20	3 Ω	600	0	3	1000	661 93056
600	70	70	25	±20	2%	170	25	8	700	662 93113
600	125	175	10	±20	0.5 Ω	400	25	7	1000	662 93114

Notes

1. Insulated version is also available.
2. Insulated version.

PTC overload protection for telecommunication

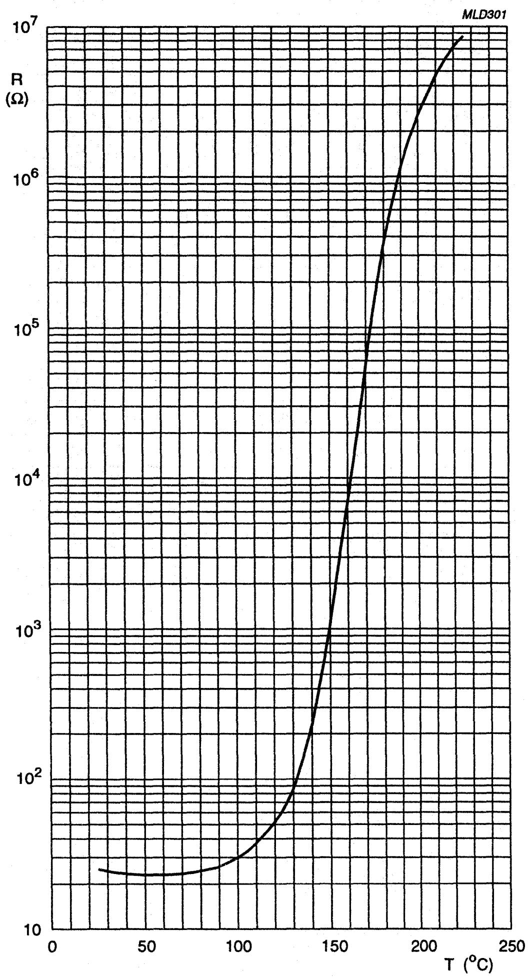


Fig.4 Typical resistance/temperature characteristics for 2322 661 93048.

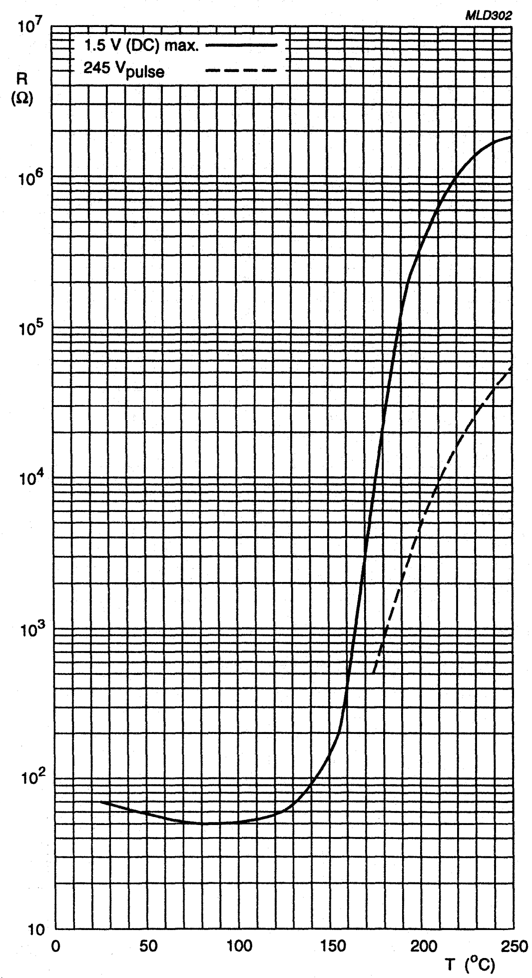


Fig.5 Typical resistance/temperature characteristics for 2322 661 93025.

PTC overload protection for telecommunication

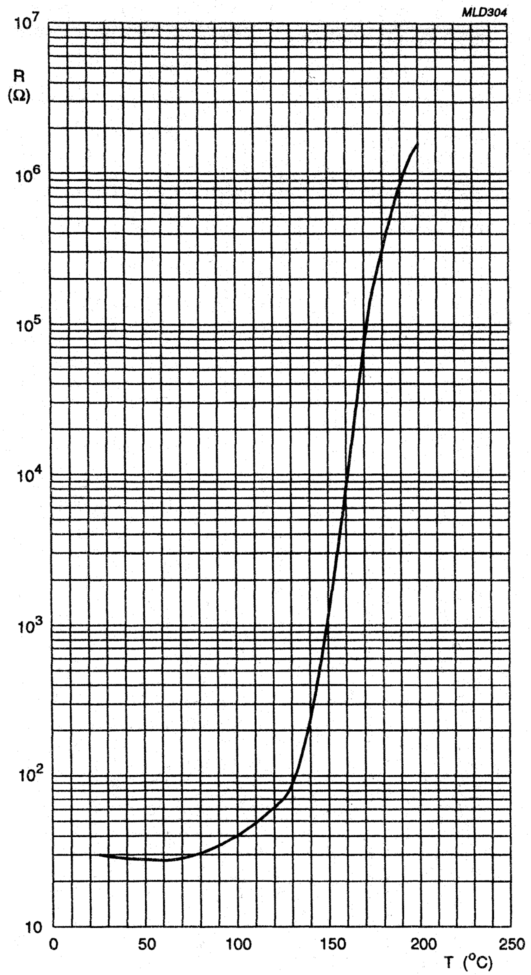


Fig.6 Typical resistance/temperature characteristics for 2322 661 93037.

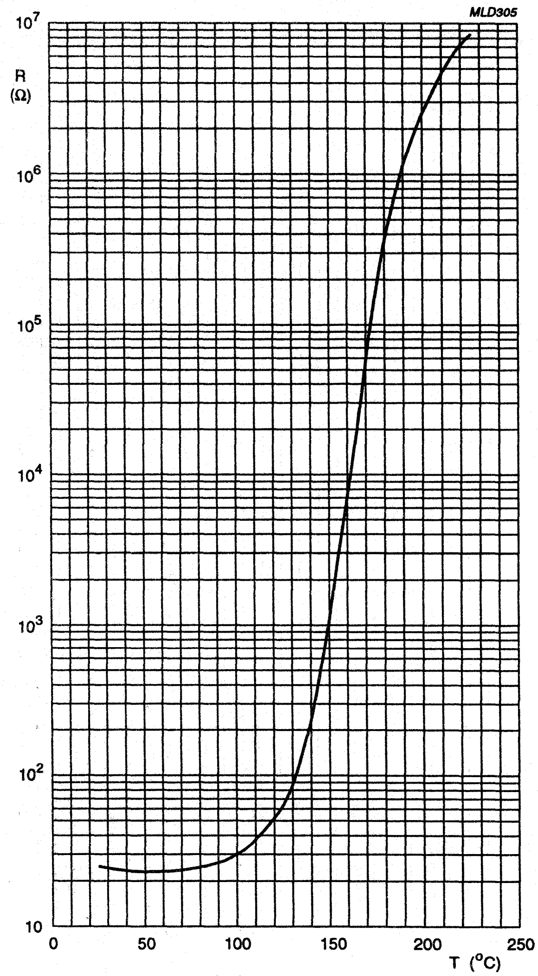


Fig.7 Typical resistance/temperature characteristics for 2322 661 93043.

PTC overload protection for telecommunication

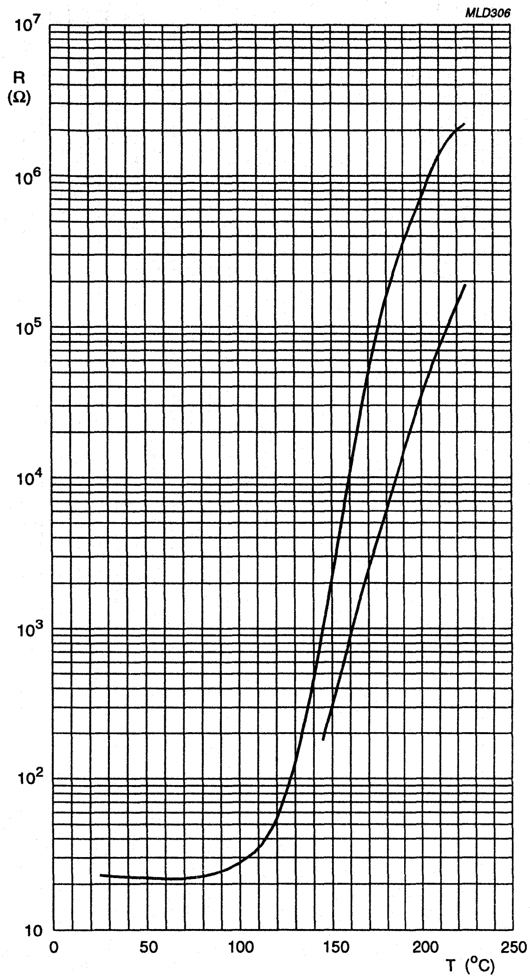


Fig.8 Typical resistance/temperature characteristics for 2322 661 93046.

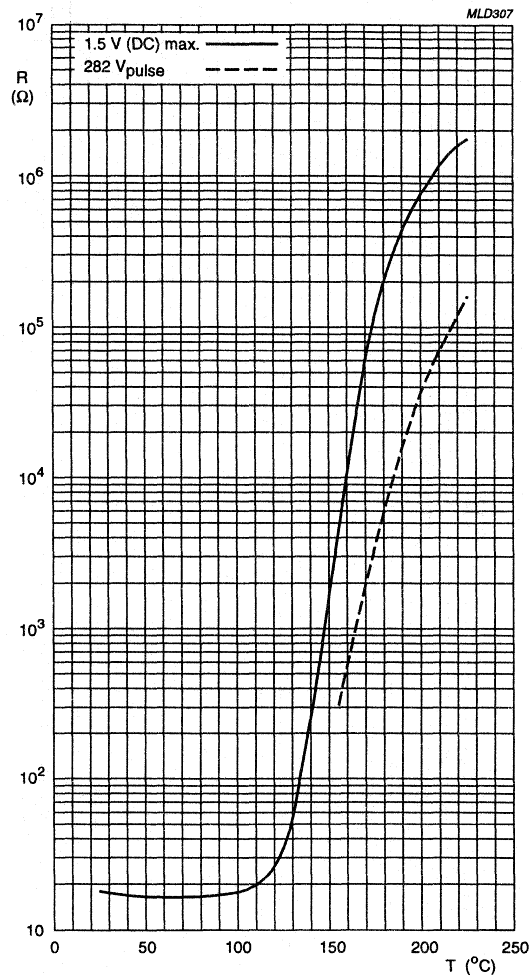


Fig.9 Typical resistance/temperature characteristics for 2322 661 93081.

PTC overload protection for telecommunication

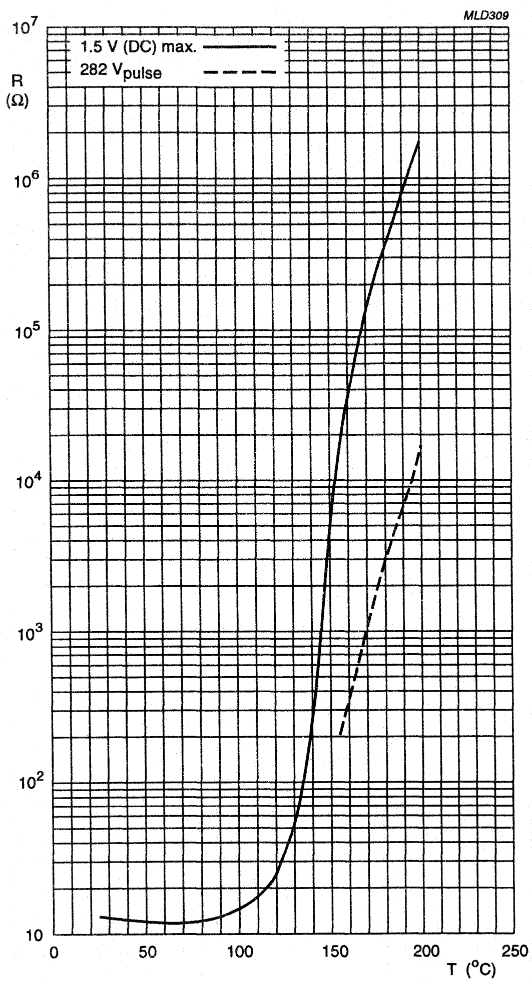


Fig.10 Typical resistance/temperature characteristics for 2322 662 93074.

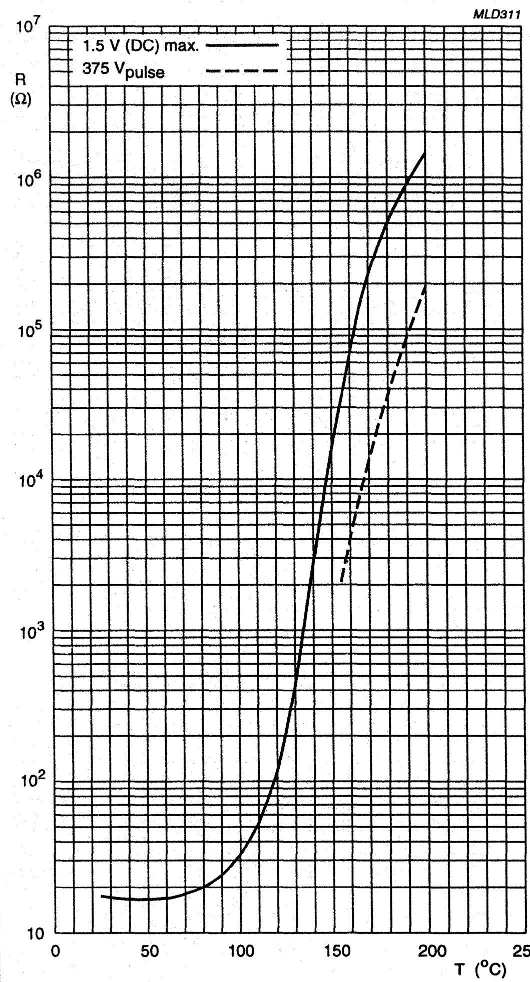


Fig.11 Typical resistance/temperature characteristics for 2322 661 93099.

PTC overload protection for telecommunication

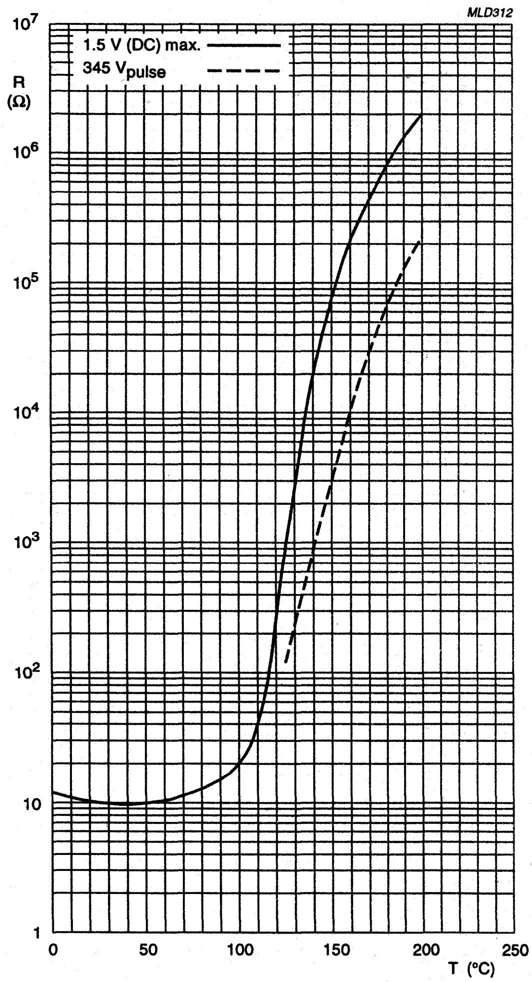


Fig.12 Typical resistance/temperature characteristics for 2322 663 93025.

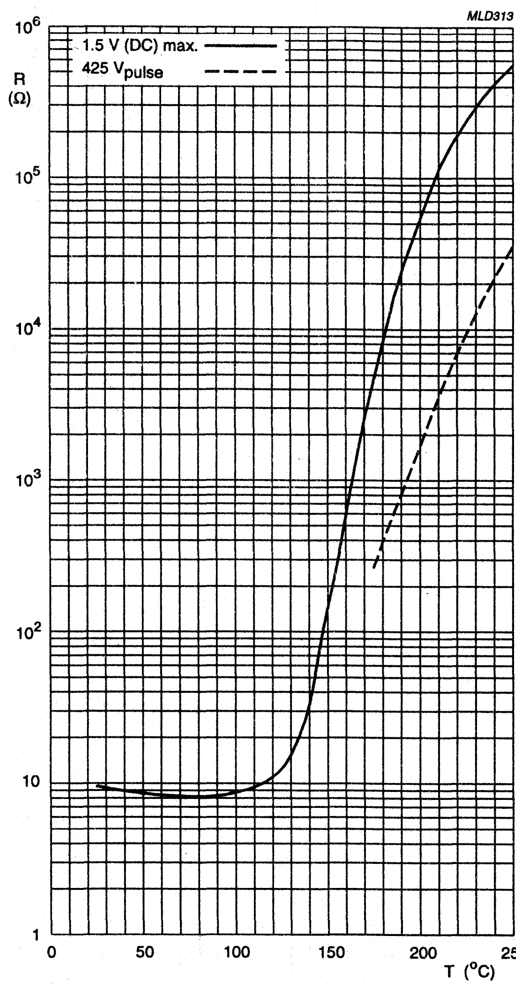


Fig.13 Typical resistance/temperature characteristics for 2322 661 93078.

PTC overload protection for telecommunication

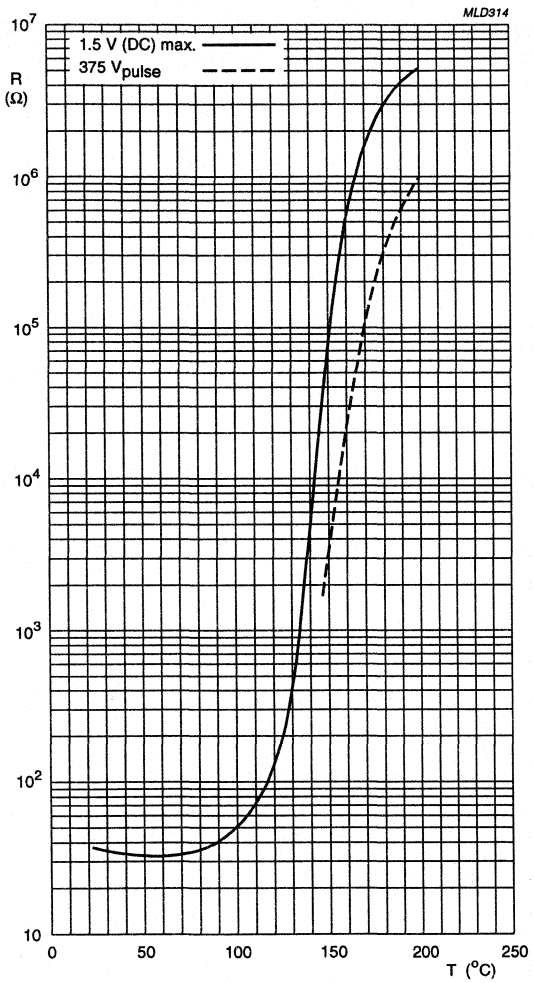


Fig.14 Typical resistance/temperature characteristics for 2322 661 93056.

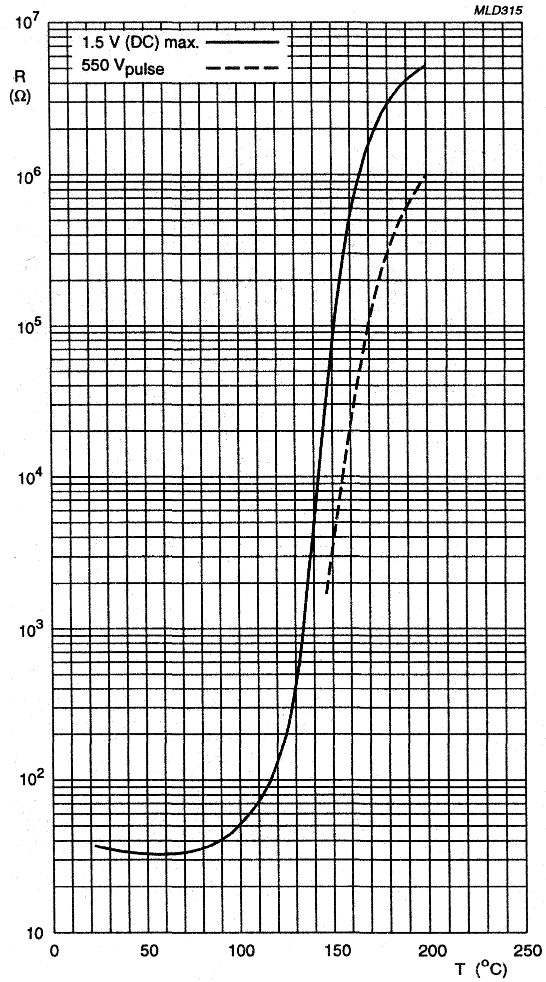


Fig.15 Typical resistance/temperature characteristics for 2322 662 93113.

PTC overload protection for telecommunication

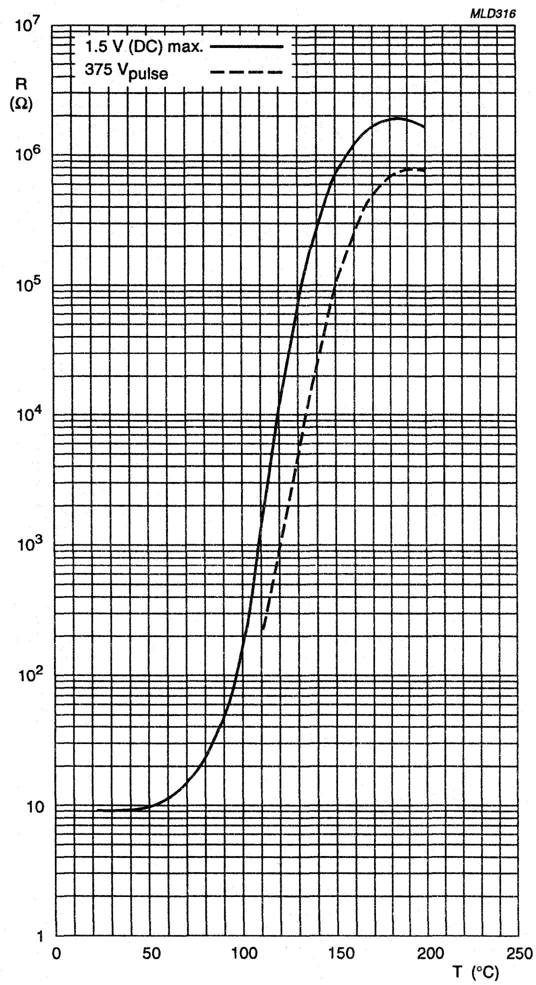


Fig.16 Typical resistance/temperature characteristics for 2322 662 93114.

PTC time delay for lighting

FEATURES

- Reliable starting time and time again
- Accurate resistance for ease of circuit design
- Small size and durable
- Available bulk-packed or taped-on-reel
- Long life: more than 20000 starts for a 20 W lamp
- Low self-inductance for high frequency applications.

APPLICATIONS

- Domestic electronics
- Industrial electronics.

DESCRIPTION

The conventional fluorescent strip lamp is rapidly being superseded by a more compact fluorescent lamp in which the old troublesome starter is replaced by an electronic ballast circuit which pre-heats the cathode to make ignition easy.

Positive Temperature Coefficient (PTC) thermistors for overload protection have proved to be the ideal electronic ballast component for companies worldwide.

When the rectified mains is first applied, the PTC thermistor is cold, so its resistance is low. The lamp voltage will be below the necessary ignition value, so the current will flow through the cathodes, heating them to their emission temperature. At the same time, the PTC thermistor will heat up to its switch temperature, whereupon its resistance will rise rapidly, allowing the lamp voltage to reach its ignition value and light the lamp.

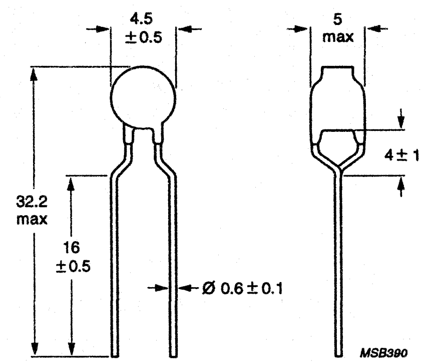
Once the lamp is lit, the cathodes are fed by a high-frequency (36 kHz) lamp supply, to avoid flicker, via two power FET switches; see Fig.4. The PTC thermistor plays no further part until the lamp is switched off, whereupon it is ready to resume its smooth-starting function.

We supply a range of overload PTC thermistors for this application (see Table 2) offering a wide choice of voltage and switch temperatures.

MOUNTING

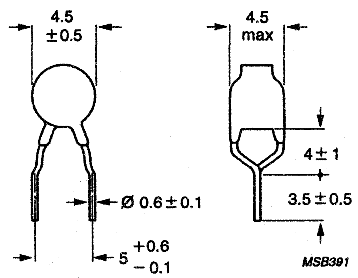
The leads are suitable for soldering in any position. The lacquer may cover the leads up to 1.0 mm from the seating plane.

MECHANICAL DATA



Dimensions in mm.

Fig.1 Component outline for 2322 660 93035 and 2322 660 93055; taped on reel.



Dimensions in mm.

Fig.2 Component outline for 2322 660 93049; packaged in bulk.

PTC time delay for lighting

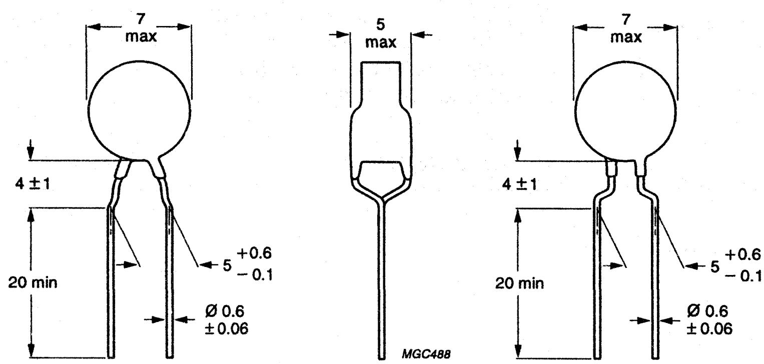


Fig.3 Component outlines for 2322 661 93102; packaged in bulk.

Table 1 Device diameter, mass, packaging quantities and catalogue numbers

DIAMETER (mm)	MASS (g)	PACKAGING	SPQ	PQ	CATALOGUE NUMBER
4.5	≈0.45	on tape	3000	3000	2322 660 93035
4.5	≈0.33	bulk	500	10000	2322 660 93049
4.5	≈0.45	on tape	3000	3000	2322 660 93055
7	≈0.66	bulk	250	5000	2322 661 93102

PTC time delay for lighting

ELECTRICAL DATA

Table 2 PTC for PLC-E lamp electronic starter; see Fig.4

R_{25} (Ω)		MAXIMUM RESISTANCE at 115 °C (Ω)	MAXIMUM VOLTAGE (PEAK VALUE) (V)	CATALOGUE NUMBER
MIN.	MAX.			
200	350	800	700	2322 660 93035
500	750	5000	700	2322 660 93049
185	300	800	700	2322 660 93055
225	375	800	1000	2322 661 93102

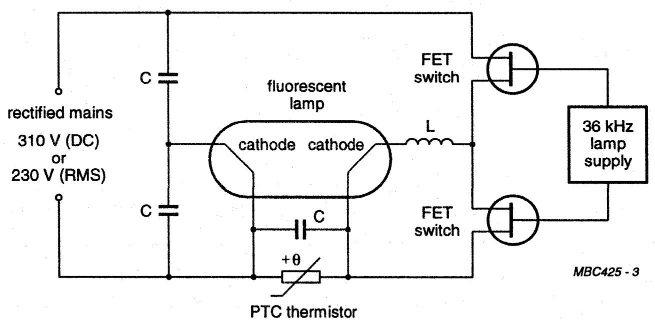
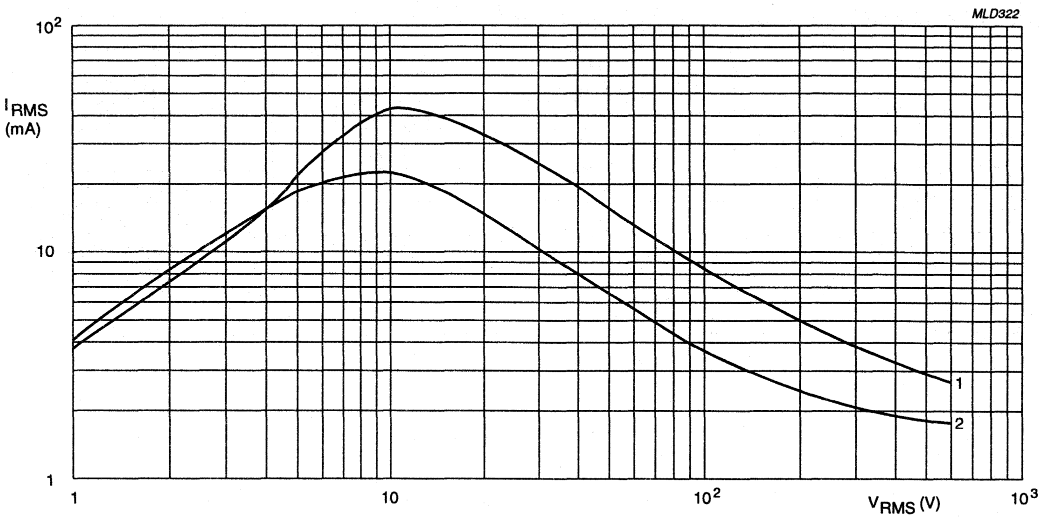


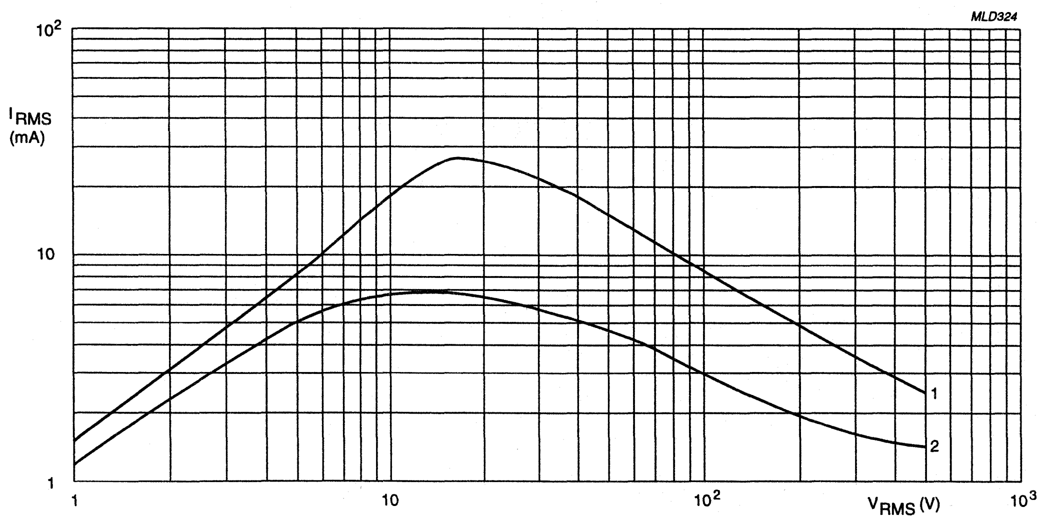
Fig.4 Typical electronic ballast circuit.

PTC time delay for lighting



Curve 1: T_{amb} = 25 °C.
Curve 2: T_{amb} = 100 °C.
Measured in still air.

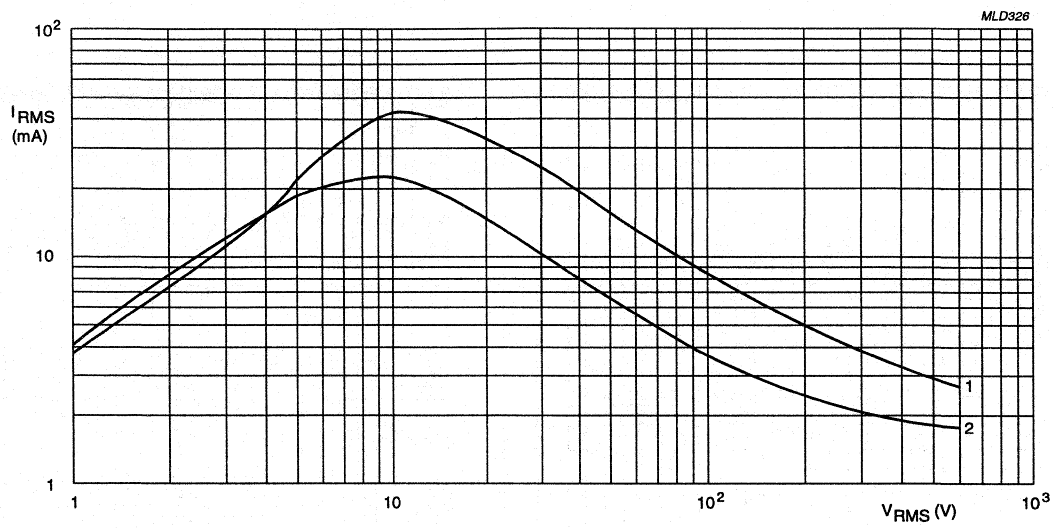
Fig.5 Typical current/voltage characteristics for 2322 6660 93035.



Curve 1: T_{amb} = 25 °C.
Curve 2: T_{amb} = 100 °C.
Measured in still air.

Fig.6 Typical current/voltage characteristics for 2322 660 93049.

PTC time delay for lighting



Curve 1: T_{amb} = 25 °C.
Curve 2: T_{amb} = 100 °C.
Measured in still air.

Fig.7 Typical current/voltage characteristics for 2322 660 93055.

PTC time delay for lighting

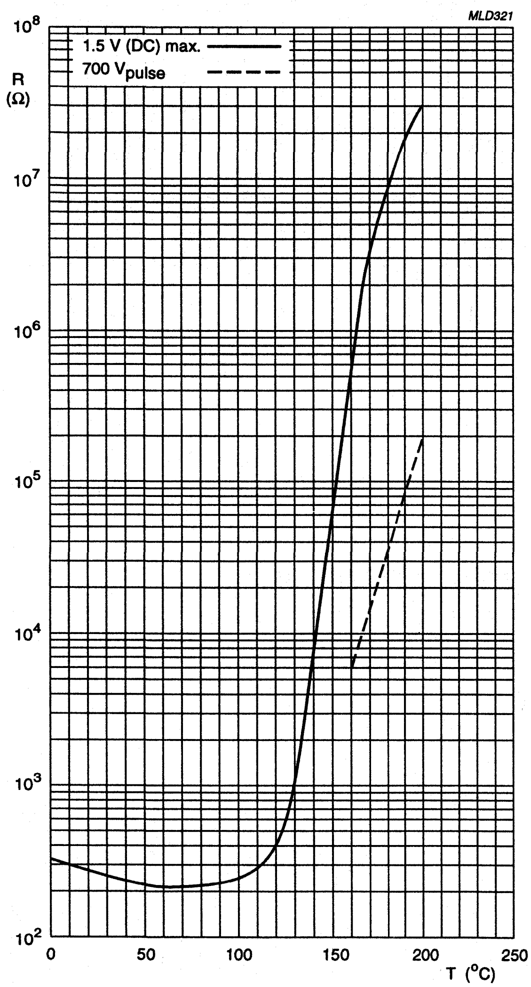


Fig.8 Typical resistance/temperature characteristics for 2322 660 93035.

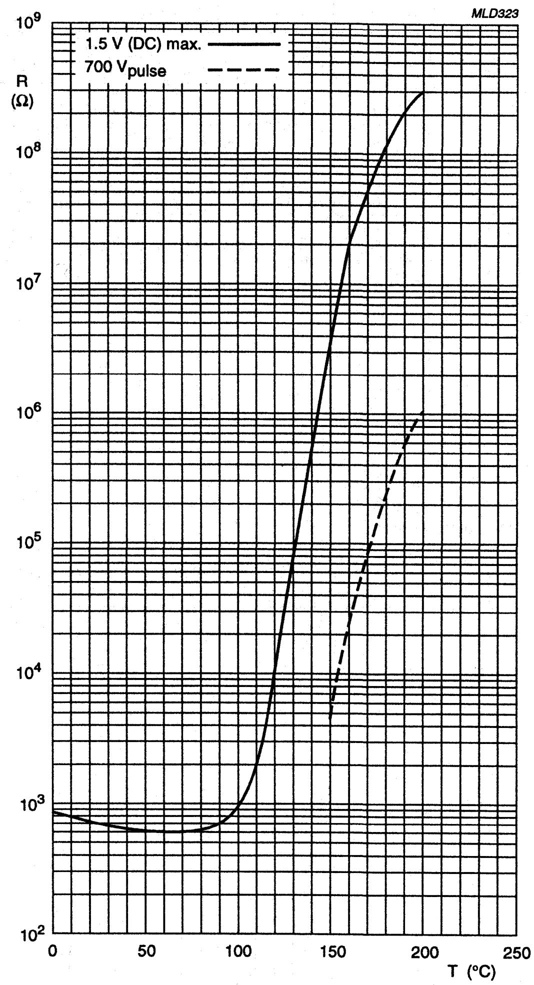


Fig.9 Typical resistance/temperature characteristics for 2322 660 93049.

PTC time delay for lighting

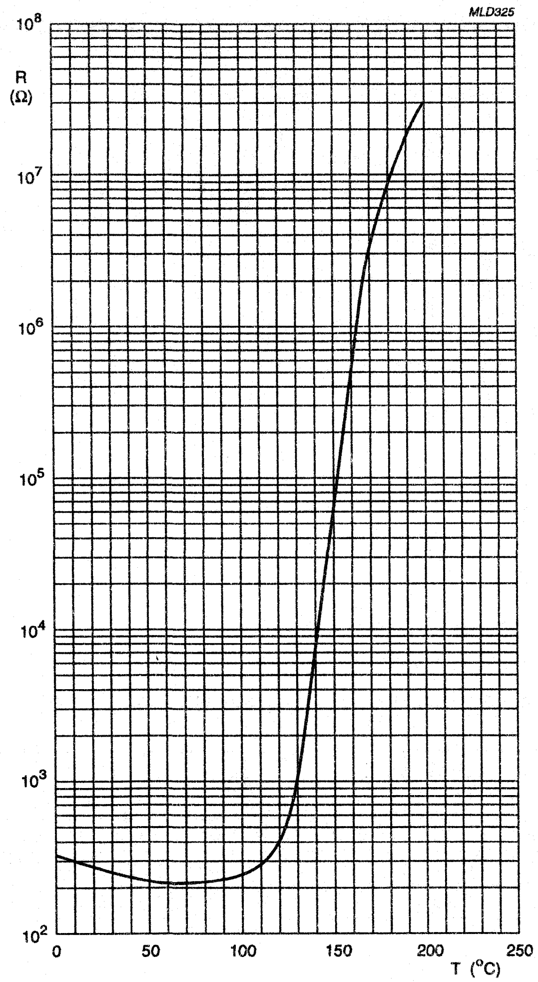


Fig.10 Typical resistance/temperature characteristics for 2322 660 93055.

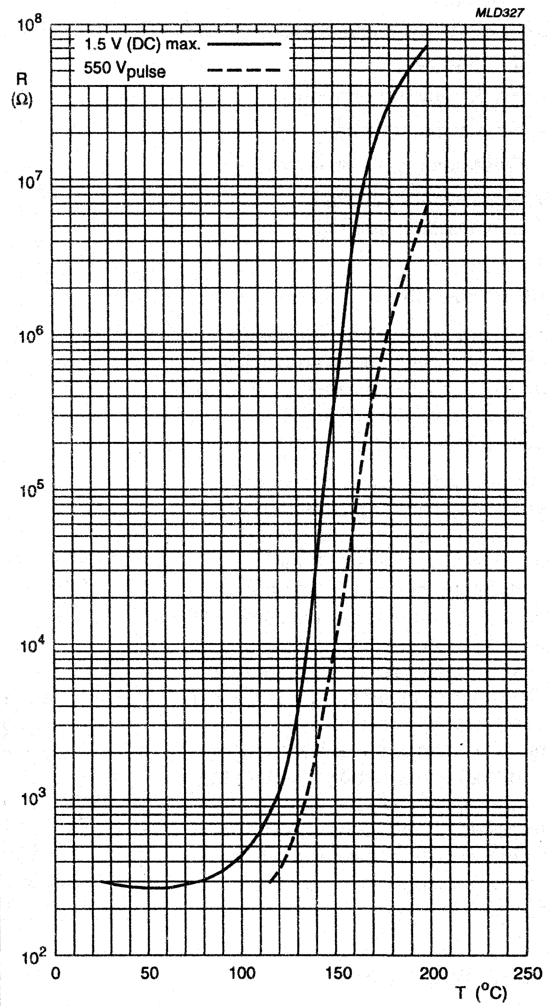


Fig.11 Typical resistance/temperature characteristics for 2322 661 93102.

PTC overload protection for instrumentation

FEATURES AND BENEFITS

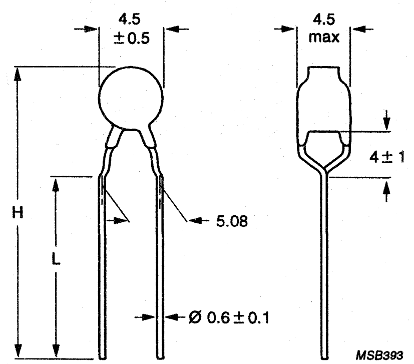
- Fast response time for rapid protection
- Automatic resetting once overload is removed
- No contacts to burn out
- No thermal runaway
- Operates on DC or AC voltage
- Small size and rugged construction; see Fig.1.

DESCRIPTION

Test and measuring instruments, such as oscilloscopes and digital multimeters, can be easily damaged if excessive voltages are applied across their input terminals.

Simple and effective overload protection can be provided by connecting a high-voltage PTC thermistor in series with the instrument; see Fig.2. Under normal conditions, the resistance of the PTC thermistor is low, so the test voltage will be measured by the instrument. Under an overload condition, the PTC thermistor will switch to its high-resistance state, absorbing the overload current and protecting the instrument. When the overload is removed, the PTC thermistor will return to its low-resistance state, ready to resume its protective function.

MECHANICAL DATA



Dimensions in mm.
For L and H, see Table 1.

Fig.1 Component outline.

Table 1 Physical dimensions, mass, packaging quantities and catalogue numbers

L (mm)	H (mm)	MASS (g)	SPQ	PQ	CATALOGUE NUMBER
20 ±3	30 ±3	≈0.44	500	10000	2322 660 93046
20 ±3	30 ±3	≈0.47	500	10000	2322 660 93034
3.5 ±0.8	12.5 ±2	≈0.32	500	25000	2322 660 93045

ELECTRICAL DATA

Table 2 Electrical data and catalogue numbers

NON-TRIP CURRENT (RMS VALUE) at 25 °C (mA)	TRIP CURRENT (RMS VALUE) at 25 °C (mA)	NOMINAL RESISTANCE at 25 °C (Ω)	MAXIMUM VOLTAGE (V)	INSULATION VOLTAGE (V)	CATALOGUE NUMBER
3	10	6100	500	–	2322 660 93046
10	20	1600	600	500	2322 660 93034
5	10	4000	500	–	2322 660 93045

PTC overload protection for instrumentation

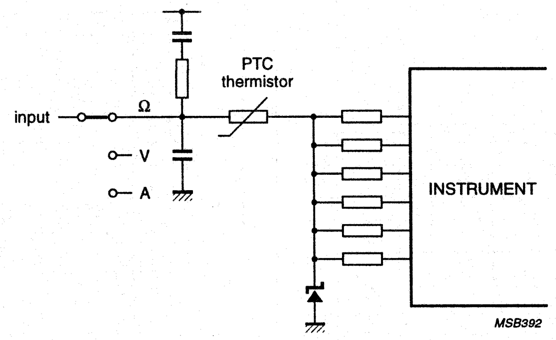


Fig.2 Typical connection of the PTC thermistor for digital multimeter protection.

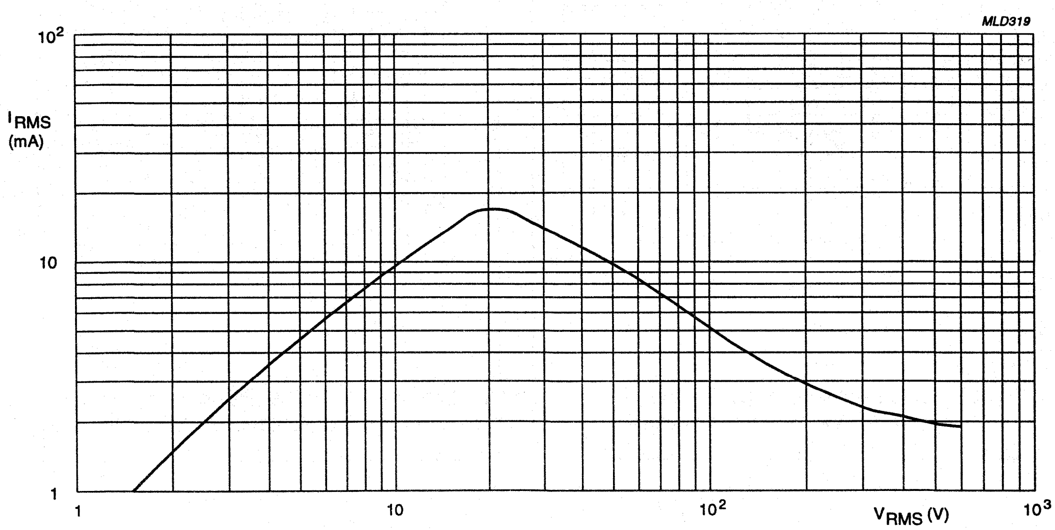


Fig.3 Typical current/voltage characteristic for 2322 660 93034.

PTC overload protection for instrumentation

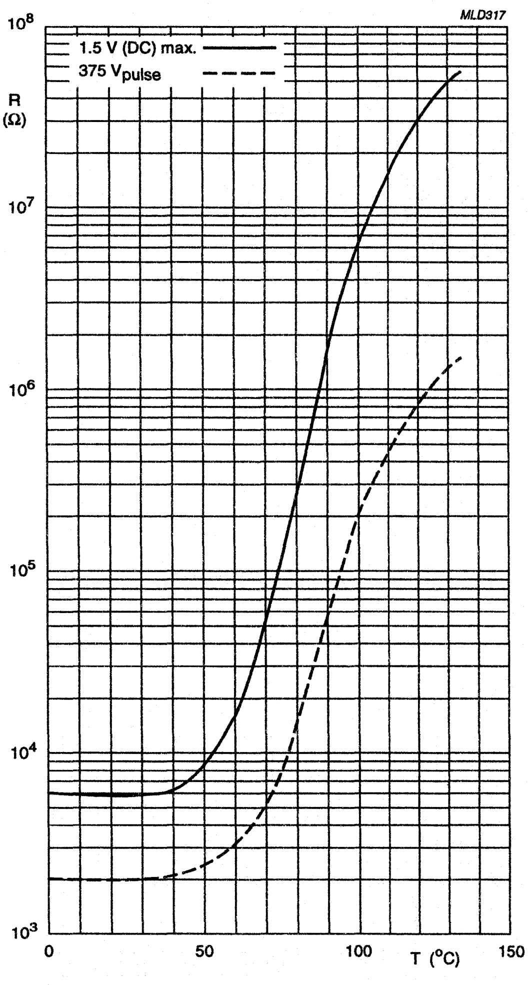


Fig.4 Typical resistance/temperature characteristic for 2322 660 93046.

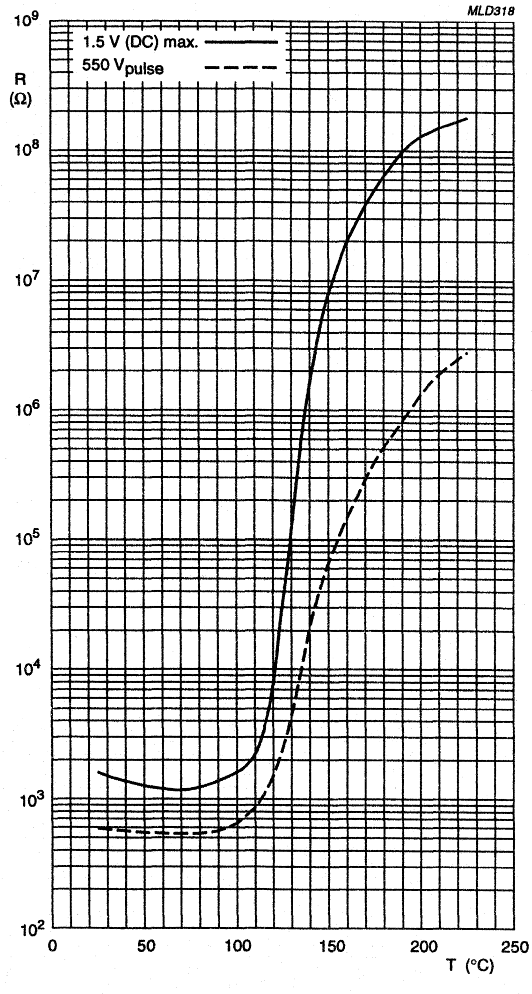


Fig.5 Typical resistance/temperature characteristic for 2322 660 93034.

PTC overload protection for instrumentation

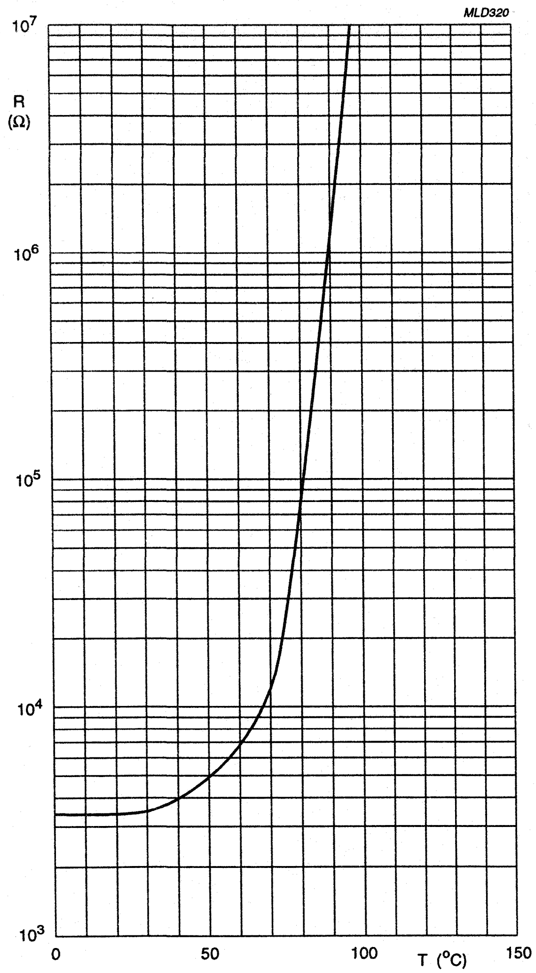


Fig.6 Typical resistance/temperature characteristic for 2322 660 93045.

VARISTORS (VDR)

GENERAL

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 stand-by value to a very low conducting value. The transient is thus absorbed and clamped to a safe level, protecting sensitive circuit components.

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.

FEATURES

- 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 time of less than 20 ns, clamping the transient the instant it occurs.
- Low stand-by power - virtually no current is used in the stand-by 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 Volume 1, Section 1"*, and manufactured using UL approved flame retardant 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 environments. 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 on in-line control.

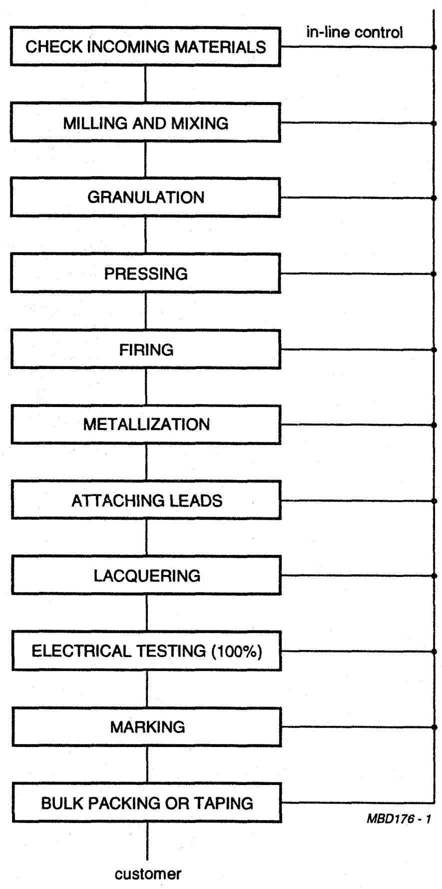


Fig.1 Manufacturing process flow chart.

Each major step in the manufacturing process shown in Fig.1 is described in the following sections:

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 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 strength tests are made. Three types of lead configuration are available; one with straight leads, one with straight leads and 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.

Electrical testing (100%)

The voltage of each component is normally checked at 2 reference currents (1 mA and another according to the application). Any rejects are automatically separated for further evaluation.

Marking

All components are laser marked.

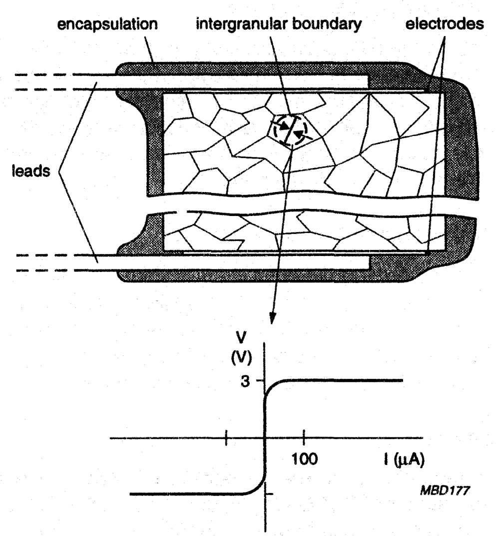


Fig.2 Structure of a varistor.

QUALITY

Approvals

- CECC 42201-802 of 1992
- UL E98144
- VDE 53138 E (for 30 V to 550 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 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 material suppliers is maintained. Incoming inspection and product 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 42000"* and *"IEC 1051-1"*. Each operator is actively engaged in quality checking. In addition, in-line inspectors and manufacturing operators make regulated spot checks as a part of our Statistical Process Control (SPC).

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 performances 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 × 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 pulse current of rise time 8 μs and decreasing time 20 μs (8 μs to 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 pulse 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 pulse current of 8 µs to 20 µs following *"IEC 60-2"*, with such an amplitude that the varistor voltage measured at 1 mA does not change by more than 10% maximum.

A surge in excess of the specified withstanding surge current may cause short circuits or package rupture with expulsion of material; it is therefore recommended that a fuse be put in the circuit using the varistor, or the varistor be used in a protective box

If more than one pulse is applied or when the pulse 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% at 1 mA.

Maximum energy

During the application of one pulse of current, a certain energy will be dissipated by the varistor. The quantity of dissipation energy is a function of:

- The amplitude of the current.
- The voltage corresponding to the peak current.
- The rise time of the pulse.
- The decrease time of the pulse; most of the energy is dissipated during the time 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.

The calculation of energy during application of such a pulse is given by the formula:

$$E = V_{peak} \times I_{peak} \times t_2 \times K$$

where:

I_{peak} = peak current

V_{peak} = voltage at peak current

β = given for $I = \frac{1}{2} \times I_{peak}$ to I_{peak}.

A low value of β corresponds to a low value of V_{peak} and then to a low value of E.

The maximum energy published does not then represent the quality of the varistor, but can be a valuable indication when comparing the various series of components which have the same varistor voltage. The maximum energy published is valid for a standard pulse of duration 10 µs to 1 000 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 dissipation are:

0.1 W for series 2322 592 .....

0.25 W for series 2322 593 .....

0.4 W for series 2322 594 .....

0.6 W for series 2322 595 .....

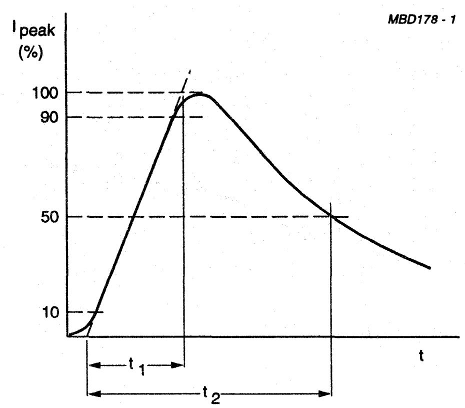


Fig.3 Maximum energy curve.

ELECTRICAL CHARACTERISTICS

Typical V/I characteristic of a ZnO varistor

The relationship between voltage and current of a varistor can be approximated to: $V = C \times I^{\beta}$

where:

- V = voltage
- C = varistor voltage at 1 A
- I = actual working current
- β = tangent of angle curve deviating from the horizontal.

EXAMPLES

When:

- C = 230 V at 1 A
- $\beta = 0.035$ (ZnO)
- $I = 10^{-3}$ A or 10^{2} A.

$V = C \times I^{\beta}$;
so that for current of 10^{-3} A: $V = 230 \times (10^{-3})^{0.035} = 180$ V
and for a current of 10^{2} A: $V = 230 \times (10^{2})^{0.035} = 270$ V.

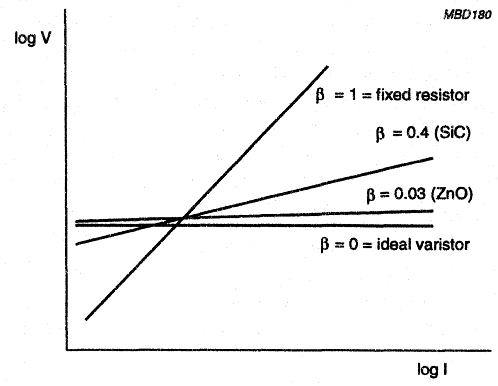
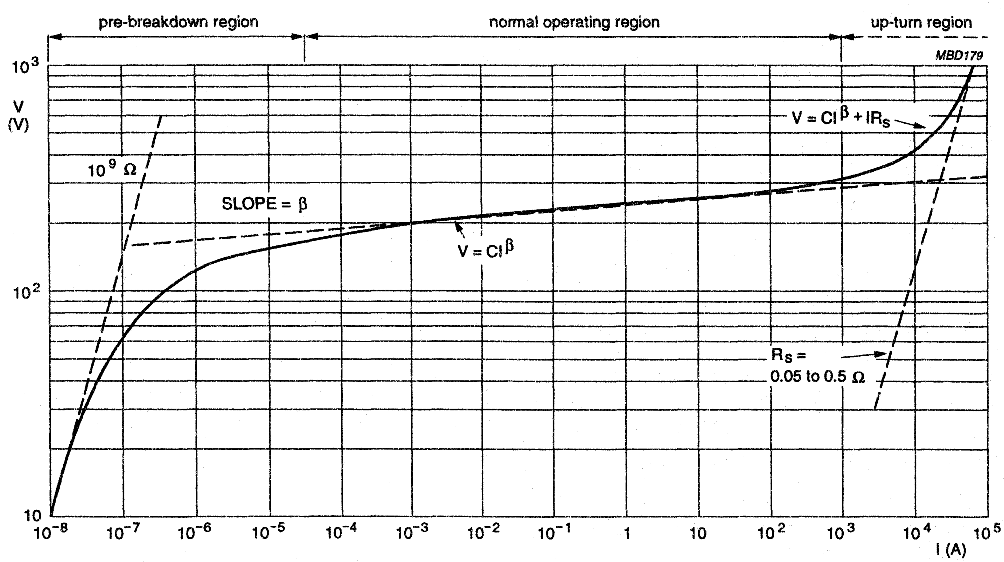


Fig.4 Varistor characteristics using different β values.



Pre-breakdown region: $V \approx \propto I$; highly temperature dependent.
Normal operating region: $V = C \times I^{\beta}$.
Up-turn region: $V = C \times I^{\beta} + I \times R_s$.

Fig.5 Typical V/I curve.

Specification of a varistor curve

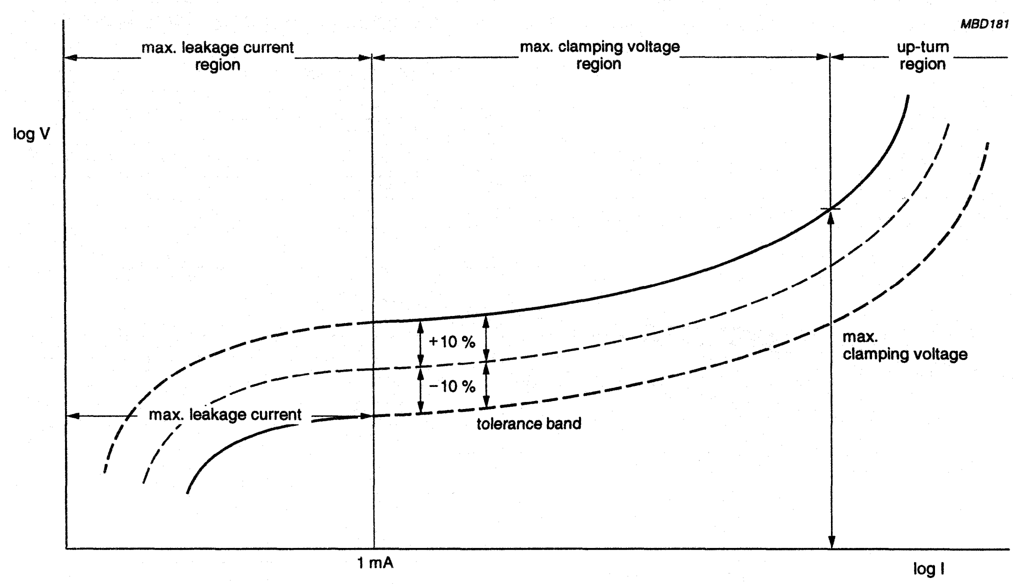


Fig.6 Working points on a varistor curve.

Figure 7 shows the various working points on the varistor curve using the series 2322 593 ....., 60 V type as an example. The electrical characteristic values are shown in Table 1.

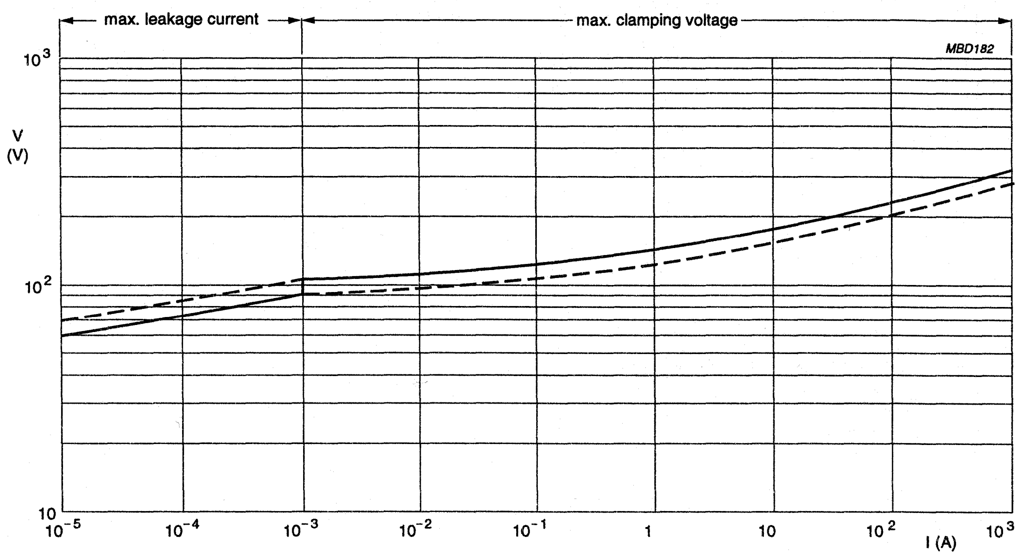
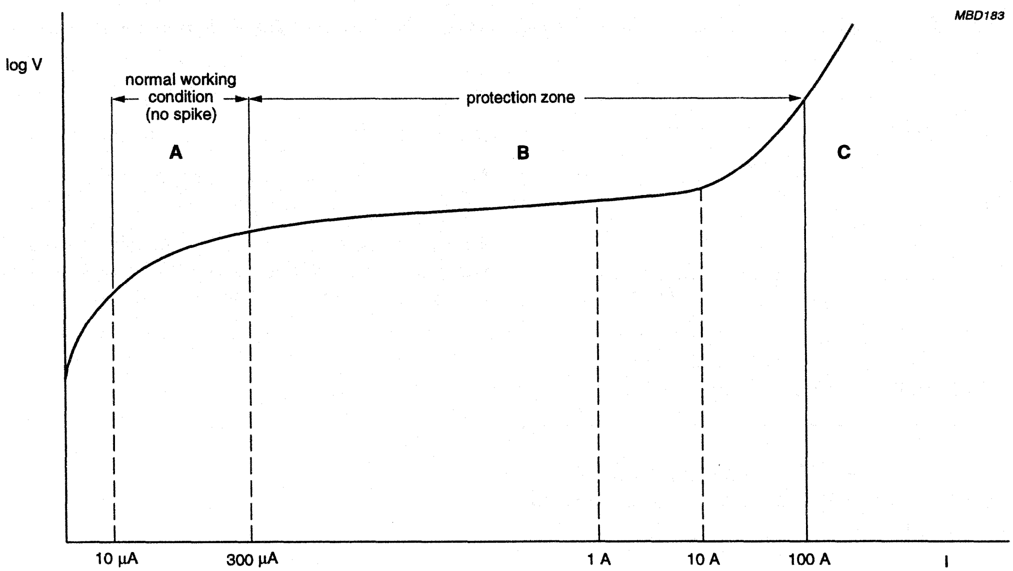


Fig.7 Curve for varistor type 2322 593 .6006

Table 1 Electrical characteristics

PARAMETER	VALUE
Maximum RMS voltage	60 V
Maximum DC working voltage	$\sqrt{2} \times 60$ V = 85 V
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} A
Transient energy	10 µs to 1000 µs: 8.3 J



The points A, B and C shown on the curve are defined in Table 2.

Fig.8 Definitions of the varistor curve.

Table 2 Varistor curve definitions

POINT	DESCRIPTION
A	Normal working zone - current is kept as low as possible in order to have low dissipation during continuous operation (between 10 μA to 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 lifetime.

TRANSIENT VOLTAGE LIMITATION WITH ZnO VARISTORS

Principles of voltage limitation

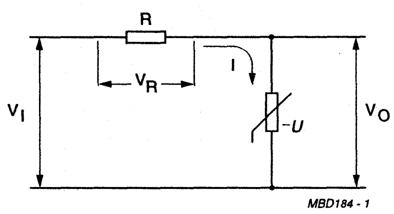


Fig.9 Voltage limitation using a varistor.

In Fig.9 the supply voltage V_I is derived by the resistance R (e.g. the line resistance) and the varistor (–U) selected for the application.

$V_I = V_R + V_O$

$V_I = R \times I + C \times I^{\beta}$

If the supply voltage varies by an amount of ΔV_I the current variation is ΔI and the supply voltage may be expressed as:

$(V_I + \Delta V_I) = R\ (I + \Delta I) + C\ (I + \Delta I)^{\beta}$

Given the small value of β (0.03 to 0.05), it is evident that the modification of $C \times I^{\beta}$ will be very small compared to the variation of $R \times I$ when V_I is increased to $V_I + \Delta V_I$. A large increase of V_I will induce a large increase of V_R and a small increase of V_O.

EXAMPLES

The varistor is a typical component of the series 2322 592 52716 (C = 520; β = 0.04) and R = 250 Ω.

For V_I = 315 V (crest voltage of the 220 V supply voltage): $I = 10^{-5}$ A, $V_R = 2.5 \times 10^{-3}$ V and V_O = 315 V.

For V_I = 500 V: $I = 10^{-1}$ A, V_R = 25 V and V_O = 475 V.

For V_I = 1 000 V: I = 1.88 A, V_R = 470 V and V_O = 530 V.

Figure 10 shows the influence of different values of series resistors on the varistor efficiency.

By drawing the load line, it is also possible to estimate the variation of the voltages V_R and V_O when V_I is increased to 500 V or 1 000 V. This effect is shown in Figs 11 and 12 respectively.

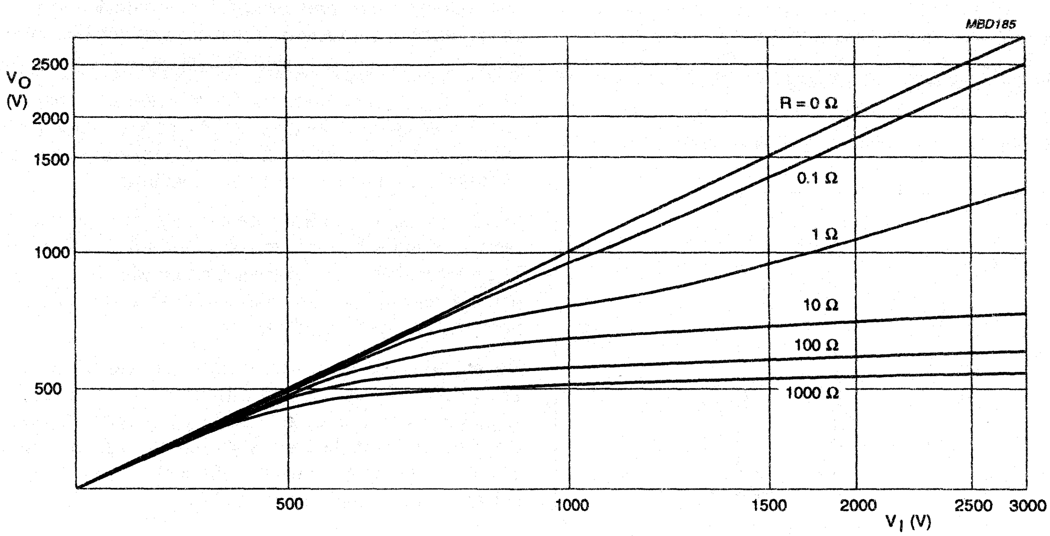


Fig.10 Influence of a series resistance on the varistor.

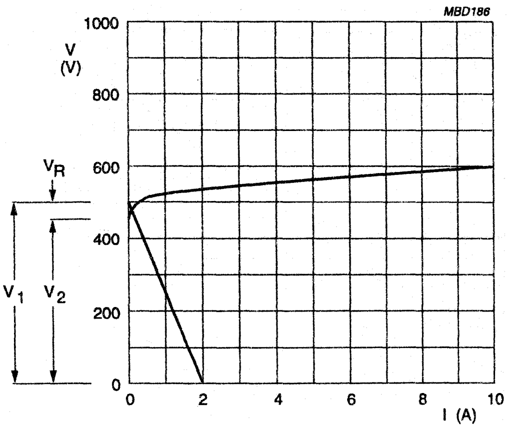


Fig.11 Influence on varistor when V_1 is 500 V (R = 250 Ω).

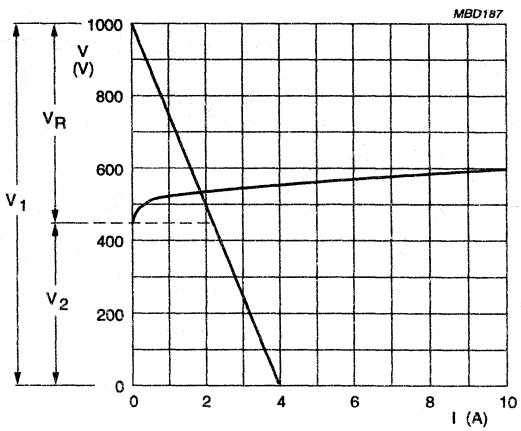


Fig.12 Influence on varistor when V_1 is 1000 V (R = 250 Ω).

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 ZnO grain resistance. For low values of applied voltages, Rp behaves as an ohmic loss.

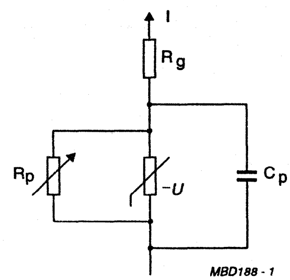


Fig.13 Equivalent circuit model.

Capacitance

Depending on area and thickness of the device, the capacitance of the varistor increases with the diameter of the disc, and decreases with its thickness.

In DC circuits, the capacitance of the varistor 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/ωC as for a usual capacitor.

Nevertheless, due to the structural characteristic 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 characteristic.

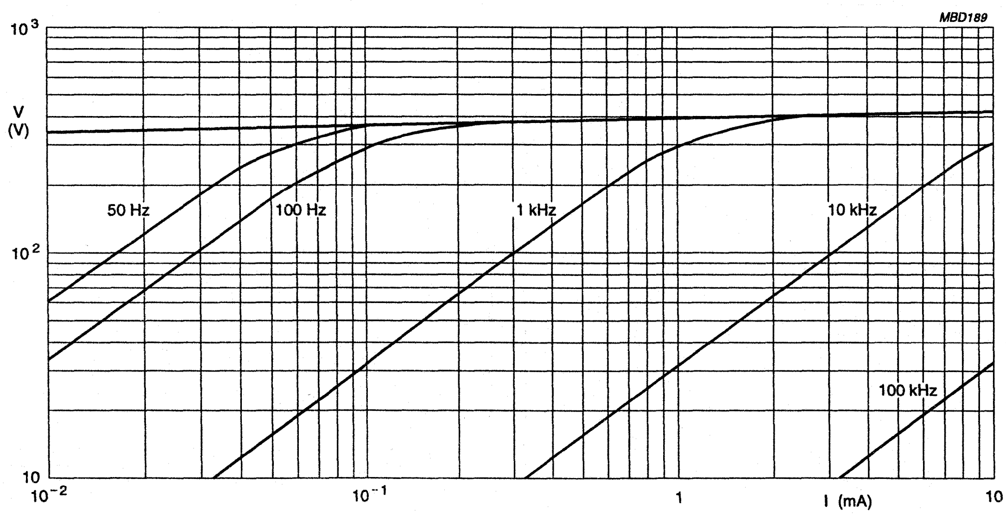


Fig.14 Effect of HF alternating current on varistor type 2322 595 52516; C = 480 pF.

Energy handling

Maximum allowable peak current and maximum allowable energy are standardized using defined pulses.

- Peak current (amperes); 8 µs to 20 µs - 1 pulse
- Energy (joules); 10 µs to 1 000 µs - 1 pulse.

EXAMPLES

Pulse life time rating of 2322 593 ....., 60 V type.

Energy capability: $E = K \times V_p \times I_p \times t_2$

1 pulse; 8 µs to 20 µs: 1200 A = 1 × 8 J

10 pulses; 8 µs to 20 µs: 300 A = 10 × 1.45 J

1 pulse; 10 µs to 1 000 µs: 33 A = 1 × 8.3 J

10 pulses; 10 µs to 1 000 µs: 11 A = 10 × 2.5 J

The maximum specified energy is defined for a maximum shift (ΔV/V) 1 mA ≤10%.

I_p = pulse current.

V_p = corresponding clamping voltage.

K depends on t_2 when t_1 is 8 to 10 µs

t_2 (µs)	K
20	1
50	1.2
100	1.3
1 000	1.4

Typical surge life rating curves (number of surges allowed as a function of pulse time and maximum current) are shown in Fig.16.

Internationally accepted pulses

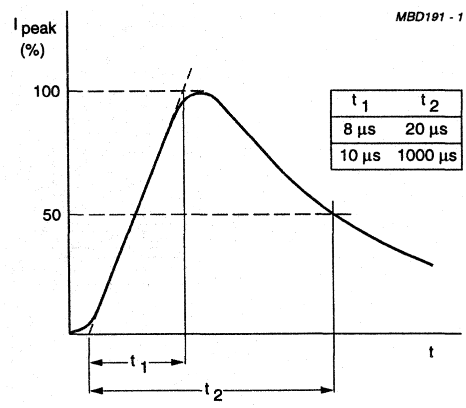


Fig.15 Standard pulse for current and maximum allowable energy calculation.

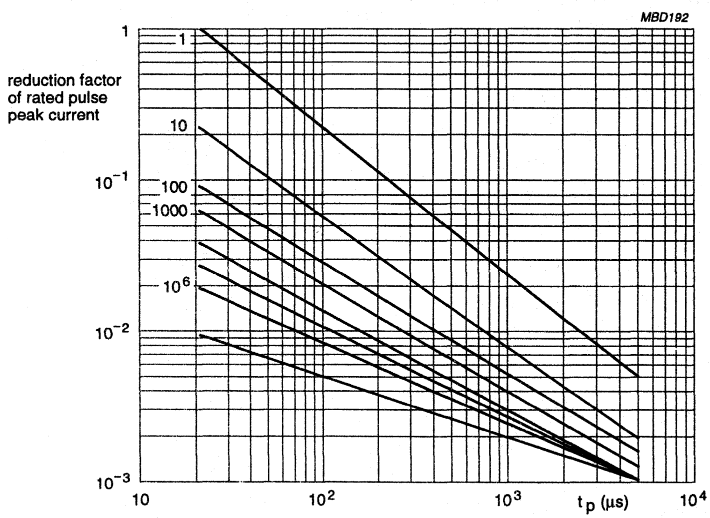
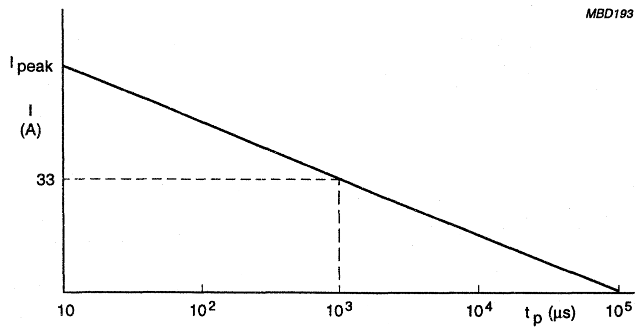
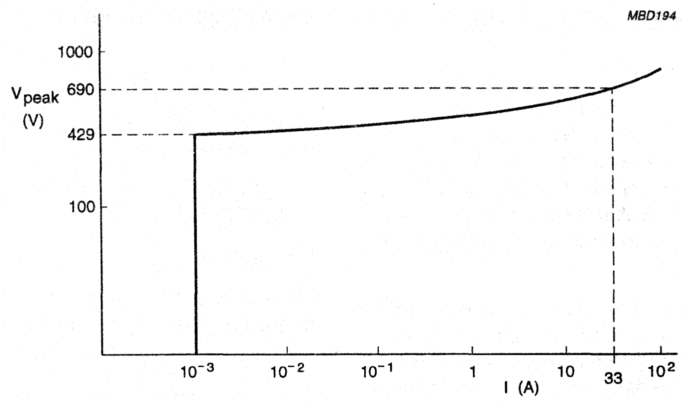


Fig.16 Maximum peak current for various number of pulses as a function of pulse duration.



Maximum energy (10 × 1000 µs): 1 pulse.
Example: 2322 593 52516 (250 V).

Fig.17 Example of selection of the maximum peak current as a function of pulse duration.



$E = K \times V_{peak} \times I_{peak} \times t_2 = 1.4 \times 700 \times 33 \times 10^{-3} = 32$ joules.

Fig.18 Example of calculation of energy for a 2322 593 52516 type, 1 pulse at the maximum peak current (33 A) for a duration $t_2 = 1000\ \mu s$ (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:

$$W = I \times V = C \times I^{\beta+1} \text{ or } K \times V^{\alpha+1}$$

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, or the permissible rating will be exceeded.

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

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:

$$P_{INST} = V \times I = V\left(K \times V^{\alpha}\right) = K \times V^{\alpha+1}$$

In the above equation, the value $V = V_{peak} \times \sin \omega t$.

During a half cycle, the dissipated power is given by:

$$P_{rms} = \frac{1}{\pi}\int_0^{\pi} K \times V_{peak}^{\alpha+1} \times (\sin\ \omega t)^{\alpha+1} \times dt$$

Since $V_{peak} = V_{rms} \times \sqrt{2}$

$$P_{rms} = \frac{1}{\pi} \times K \times V_{rms}^{\alpha+1} \times (\sqrt{2})^{a+1} \times \int_0^{\pi} (\sin \omega t)^{\alpha+1} \times dt$$

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 on the value of α and not more on the K value as shown in the formula:

$$P = \frac{\frac{1}{\pi} \times K \times V_{rms}^{\alpha+1} \times 2^{(a+1)/2} \times \int_0^{\pi} (\sin \omega t)^{\alpha+1} \times dt}{K \times V^{a+1}}$$

$$P = \frac{1}{\pi} \times 2^{(a+1)/2} \times \int_0^{\pi} (\sin \omega t)^{\alpha+1} \times dt$$

P as been calculated by successive application of a reduction formula; see Table 3.

Table 3 Power ratios

α	P	α	P	α	P	α	P	α	P
1	1.0	11	14.4	21	344	31	9.135	41	255.646
2	1.2	12	19.6	22	477	32	12.776	42	358.778
3	1.5	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	2.5	15	50.3	25	1264	35	34.482	45	977.622
6	3.29	16	69	26	1763	36	48.301	46	1373.365
7	4.375	17	95	27	2439	37	67.149	47	1914.51
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	183.66	50	5275.834

Temperature coefficient

In the leakage current region of the V/I characteristic, the normal equation $V = C \times I^{\beta}$ 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 temperatures. The relationship between the temperature and the current at a given voltage can be expressed by:

$I = I_0 \times e^{KT}$

where:

I_0 is the limiting current a 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 % per 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 dischargers

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 into the capacitance of the coil which is generally very low.

$E = \frac{1}{2} \times L \times I^2 = \frac{1}{2} \times C \times V^2$

EXAMPLES, USING THE FOLLOWING VALUES

Mains voltage = 220 V (RMS); allowable peak voltage = 340 V

Line inductance: $L = 20\ \mu H = 20 \times 10^{-6}$ H

Line capacitance: $C = 300$ nF $= 0.3 \times 10^{-6}$ H

Line resistance: 0.68 Ω.

In the event of a short circuit:

Load current: $I_L = \frac{V}{R} = \frac{340\ V}{0.68\ \Omega} = 500\ A$

Energy stored:
$E = \frac{1}{2} \times 20 \times 10^{-6} \times 25 \times 10^4 = 2.5$ J(W.s).

In the event of a fuse going open circuit:

The energy goes from inductance L towards line capacitance:

$$V_C = \sqrt{\frac{2E}{C}} = \sqrt{\frac{2 \times 2.5}{0.3 \times 10^{-6}}} = 4082\ V$$

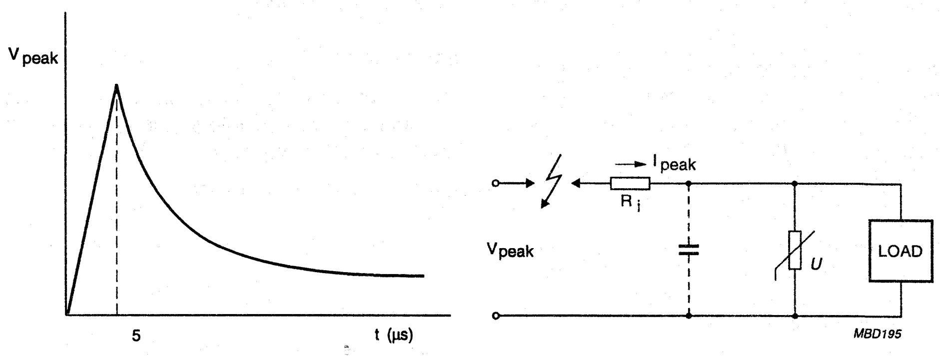


Fig.19 Source of transient.

The line impedance becomes high when the fuse goes open circuit (resistance against high voltage peak in a very short time).

$$R_i = \omega L = 2\pi f L$$

Since the rise time of the pulse is 5 μs, the frequency f = 50 kHz.

$$R_i = 6.28 \times 50 \times 10^3 \times 20 \times 10^{-6} = 6.28\ \Omega$$

$Z_i = 6.28 + 0.68 = 6.96\ \Omega$

$V_{Ri} = 6.96 \times 500 = 3480$ V

$V_{VDR} = 4082 - 3480 = 602$ V.

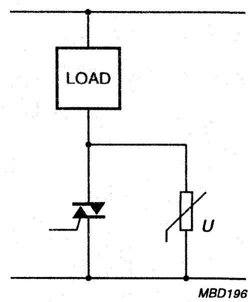
VARISTOR APPLICATIONS

Varistors may be used in many applications, including:

- Computers
- Timers
- Amplifiers
- Oscilloscopes
- Medical analysis equipment
- Street lighting
- Tuners
- Televisions
- Controllers
- Industrial power plants
- 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

For suppression of mains-borne transients in domestic appliances and industrial equipment, see Figs 20, 21, 22 and 23.



Type 2322 592 ..... or 2322 593 .....

Fig.20 Suppression via load.

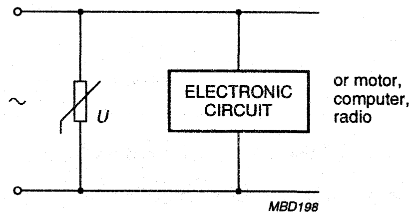


Fig.21 Suppression directly across mains.

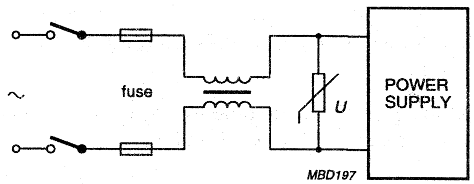


Fig.22 Switched-mode power supply protection.

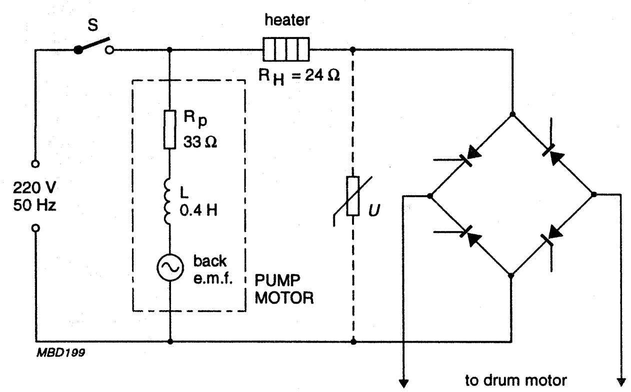


Fig.23 Protection of a thyristor bridge in a washing machine.

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:

$$I^2 \times \frac{L}{2} = \frac{0.4}{2} = 200 \text{ mJ}$$

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. Arching 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: $V = C_{MAX} \times I^{\beta} = 600$ 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.

For suppression of internally generated spikes in electronic circuits, see Figs 24 and 25.

In both examples shown in Figs 24 and 25, type 2322 592 ..... should be used for up to approximately 50 A, and type 2322 593 ..... up to approximately 120 A.

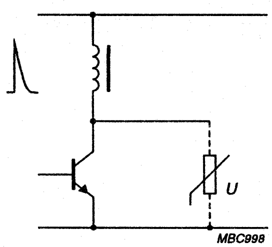


Fig.24 Varistor used across a transistor or coil in a television circuit.

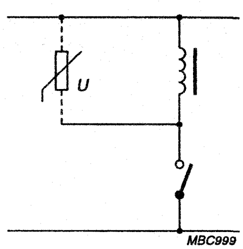


Fig.25 Varistor used across a switch or coil.

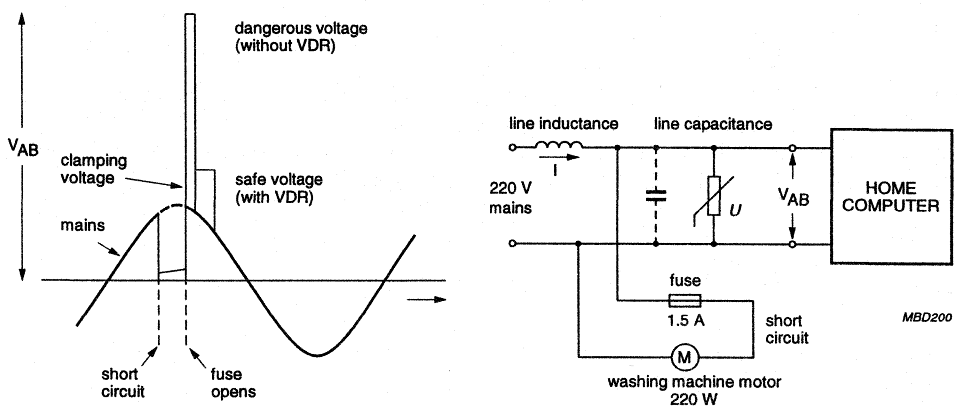


Fig.26 Influence of a transient on the mains voltage.

SELECTION OF THE CORRECT VARISTOR TYPE

In order to select a ZnO varistor for a specific application, the following points must first be considered:

1. The normal operating conditions of the apparatus or system, AC or 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, see Figs 27 and 28.

Figure 27 determines the necessary steady state voltage rating (i.e. working voltage) and Figure 28 determines the correct size (i.e. correct energy absorption).

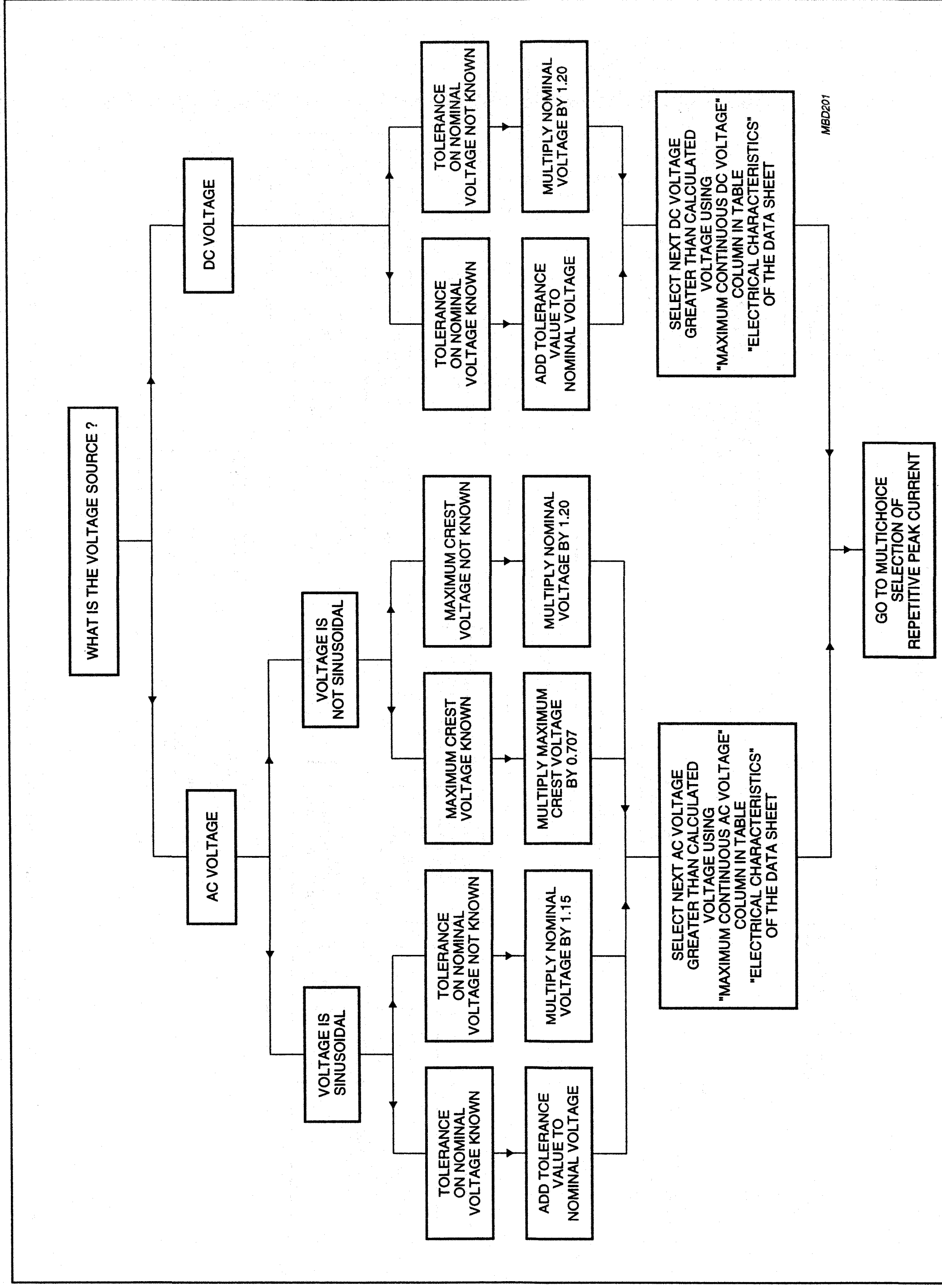


Fig.27 Multichoice selection chart to determine the necessary steady state voltage rating (i.e. working voltage).

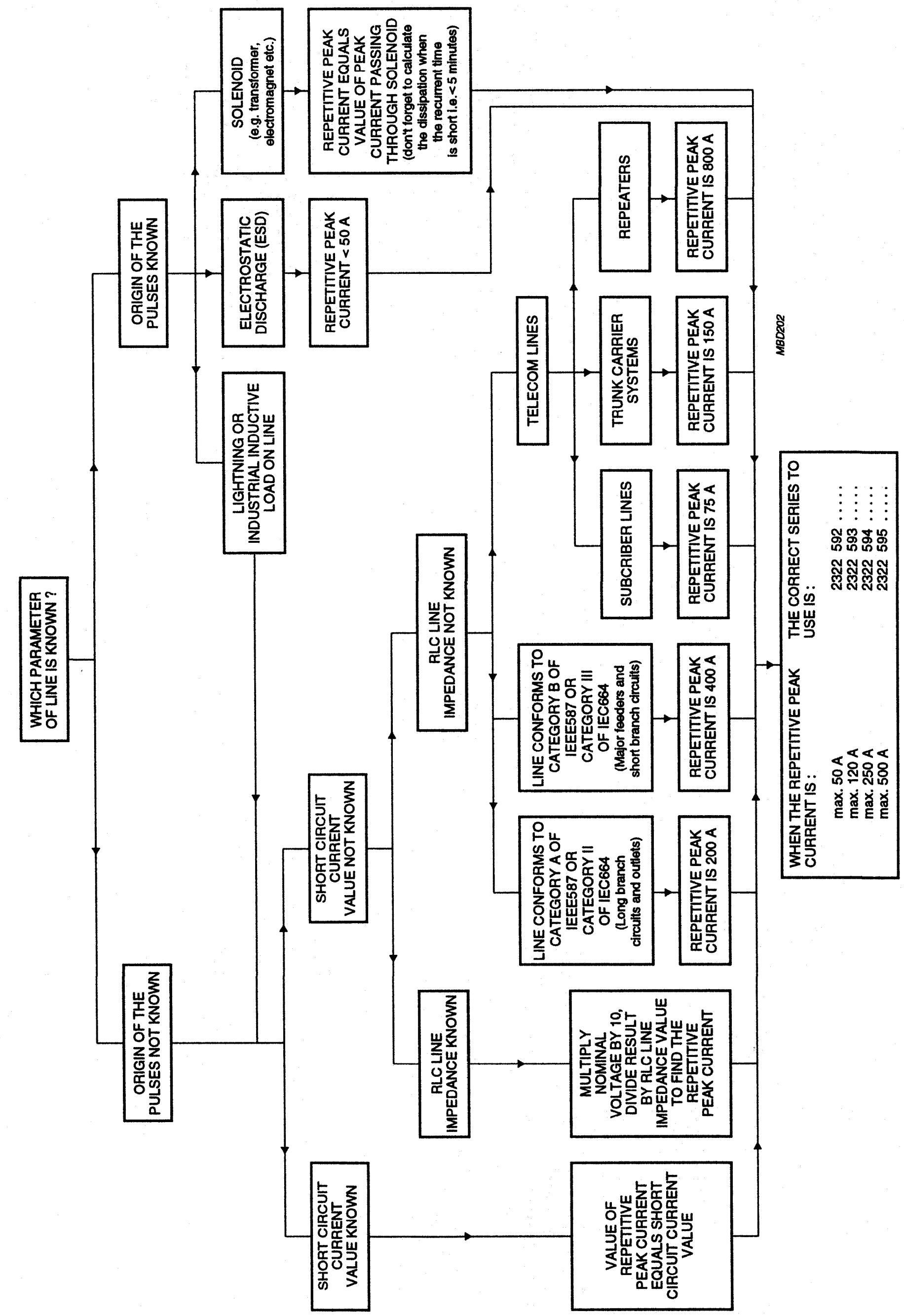


Fig.28 Multichoice selection chart to determine the correct size (i.e. correct energy absorption).

PREFERRED TYPES

For specific details refer to the relevant data sheet in this handbook.

VOLTAGE			CATALOGUE NUMBER 2322 592/3/4/5 .....
$U_{eff\,max}$ (V)	U_{max} (V)	U_V at 1 mA (V)	
30	38	47	53006
35	45	56	53506
40	56	68	54006
50	65	82	55006
60	85	100	56006
75	100	120	57506
95	125	150	59506
130	170	205	51316
140	180	220	51416
150	200	240	51516
175	225	275	51716
230	300	360	52316
250	320	390	52516
275	350	430	52716
300	385	470	53016
320	420	510	53216
385	505	620	53816
420	560	680	54216
460	615	750	54616
510	670	820	55116
550	745	910	55516

Varistors 2322 592 to 2322 595

FEATURES

- Zinc oxide disc, epoxy coated
- Straight leads
- Straight leads with flange (2322 592 and 593 series only)
- Kinked leads.

APPLICATION

- Suppression of transients.

DESCRIPTION

The varistors consist of a disc of low-β ceramic material with two tinned solid copper leads. They are coated with a layer 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"*.

MARKING

The varistors are marked with the following information:

- Maximum continuous RMS voltage
- Series number (592, 593, 594 or 595)
- Manufacturers logo
- Date of manufacture.

ORDERING INFORMATION

The varistors are available in a number of packaging options:

- Bulk
- On tape on reel
- On tape in ammopack.

The basic ordering code for each option is given in Tables 6, 7 and 8. To complete the catalogue number and to determine the required operating parameters, see Table 4.

MOUNTING

The varistors are suitable for processing on automatic insertion and cutting and bending equipment.

Varistors with flanged leads provide better positioning on printed-circuit boards (PCB) and more accurate control over component height. This is important for hand mounting and automatic insertion techniques; see Fig.4.

Soldering

≤ 240 °C; duration ≤ 5 s.

≤ 260 °C; duration ≤ 5 s.

INFLAMMABILITY

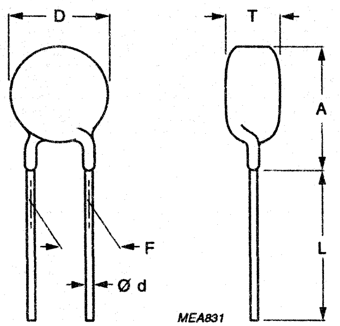
The varistors are non-flammable.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Maximum continuous voltage:		
RMS	14 to 550	V
DC	18 to 745	V
Maximum non-repetitive transient current I_{nrp} (8 × 20 μs)	100 to 4500	A
Robustness of terminations	10	N
Drop test:		
Height of fall	1	m
Detailed specification	based on CECC 42000	
Climatic category	40/085/56	

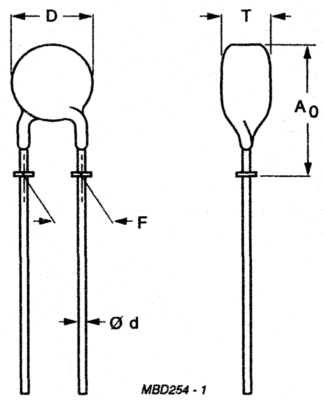
Varistors 2322 592 to 2322 595

MECHANICAL DATA



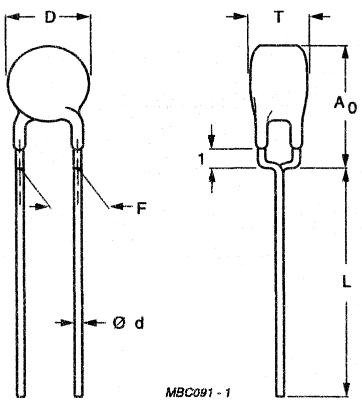
For dimensions, see Table 1.
For dimension T, see Table 2.

Fig.1 Outline of component with straight leads.



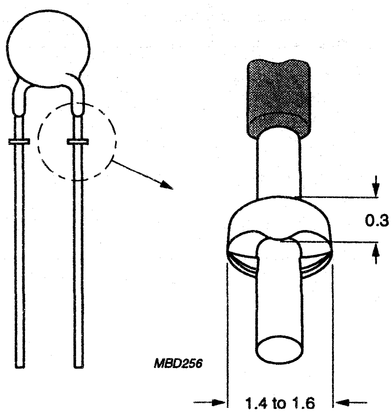
For dimensions, see Table 1.
For dimension T, see Table 2.

Fig.2 Outline of component with straight leads and flange.



For dimensions, see Table 1.
For dimension T, see Table 2.

Fig.3 Outline of component with kinked leads.



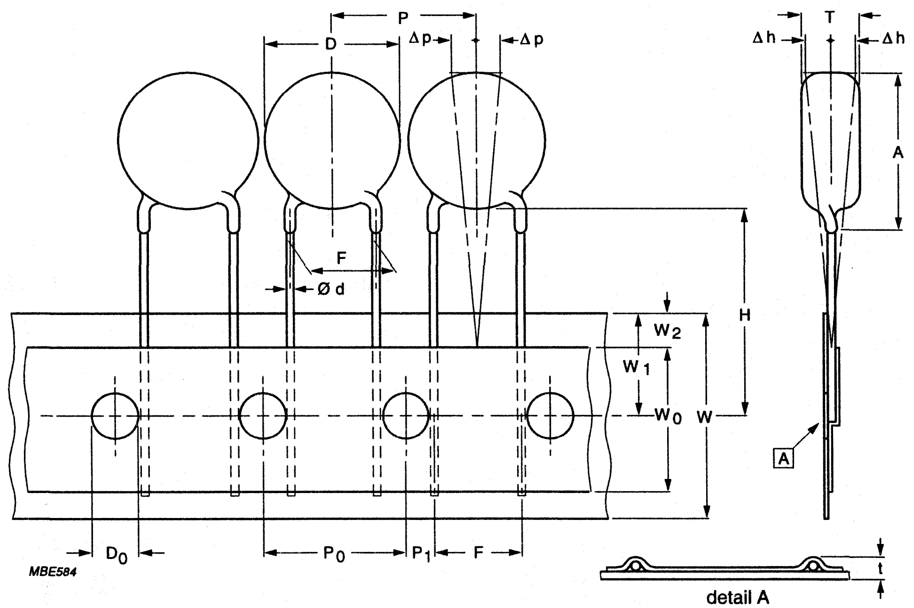
Dimensions in mm.

Fig.4 Outlines of flanged leads.

Table 1 Component dimensions and catalogue numbers

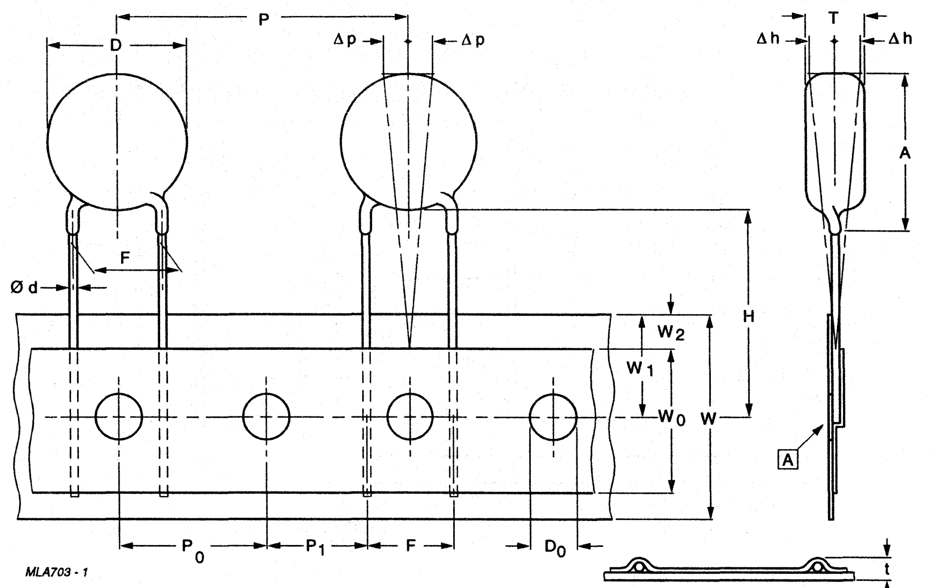
D MAX. (mm)	A MAX. (mm)	A_0 MAX. (mm)	L MIN. (mm)	T MAX. (mm)	T MIN. (mm)	Ød (mm)	F (mm)	CATALOGUE NUMBER
7.0	9.0	11.0	27.0	4.1	6	0.6 +0.0/–0.02	5 +0.6/–0.1	2322 592 .....
9.0	11.0	13.0	27.0	4.1	6	0.6 +0.0/–0.02	5 +0.6/–0.1	2322 593 .....
13.5	15.5	18.0	17.0	4.4	7	0.8 +0.0/–0.02	7.5 ±0.8	2322 594 .....
17.0	19.0	23.0	16.0	4.4	7	0.8 +0.0/–0.02	7.5 ±0.8	2322 595 .....

PACKAGING



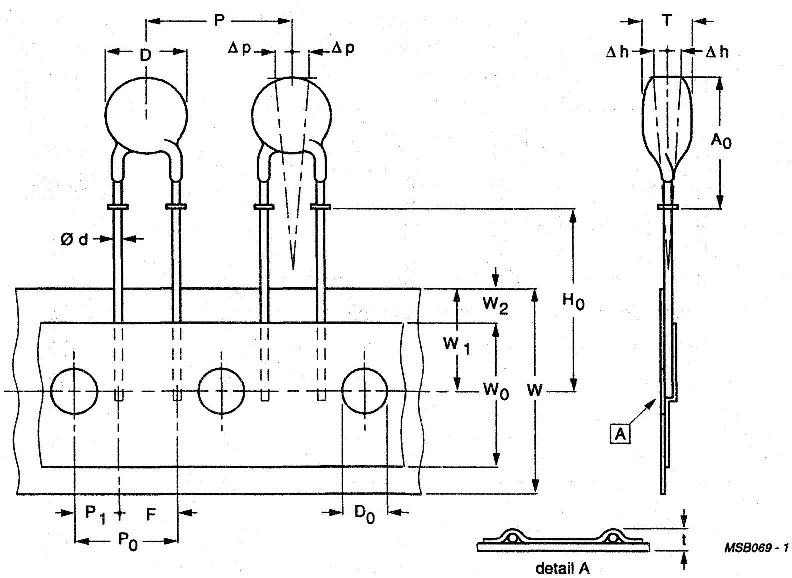
For dimensions, see Table 2.

Fig.5 Taped version with straight leads (only for 2322 592 and 2322 593 series).



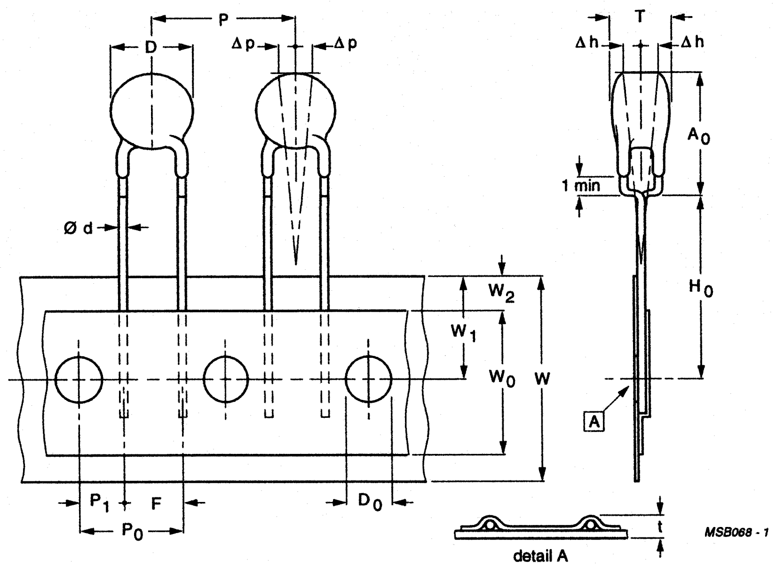
For dimensions, see Table 2.

Fig.6 Taped version with straight leads (only for 2322 594 and 2322 595 series).



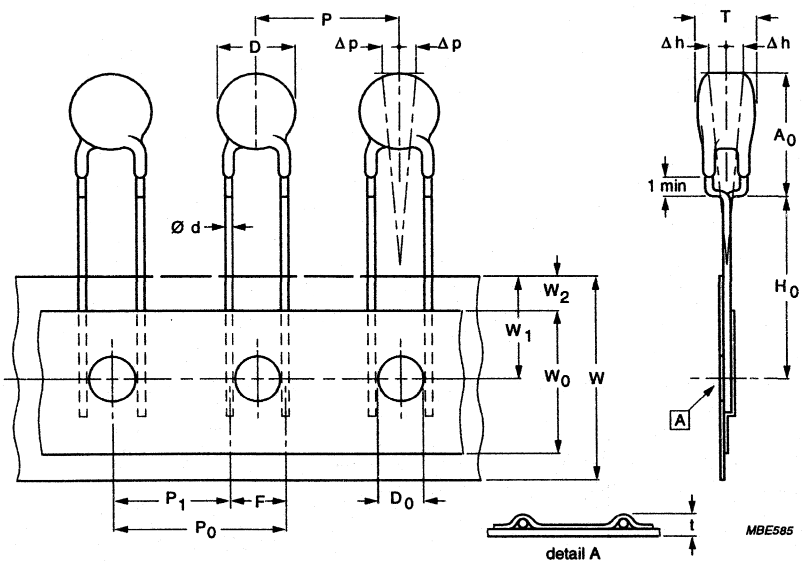
For dimensions, see Table 2.

Fig.7 Taped version with flanged leads (only for 2322 592 and 2322 593 series).



For dimensions, see Table 2.

Fig.8 Taped version with kinked leads (only for 2322 592 and 2322 593 series).



For dimensions, see Table 2.

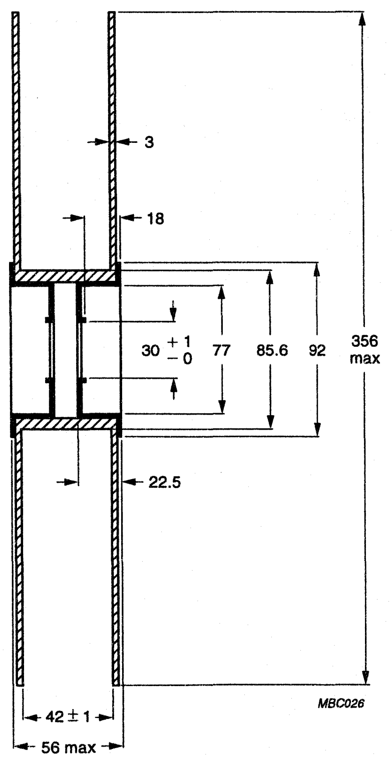
Fig.9 Taped version with kinked leads (only for 2322 594 and 2322 595 series).

Table 2 Taping data (based on *"IEC 286-2"*)

SYMBOL	PARAMETER	DIMENSIONS NOMINAL (mm)	TOLERANCE (%)	REMARKS
D	body diameter	see Table 1		
T	total thickness	see Table 1		
A_0; A	mounting height	see Table 1		
Ød	lead diameter	see Table 1		
F	lead to lead distance	see Table 1		guaranteed between component and tape
P	component pitch	12.7 or 25.4	±1.0	
P_0	feed hole pitch	12.7	±0.3	cumulative pitch error ±1 mm/20 pitches
P_1	feed hole centre to lead centre	3.81 or 8.95	±0.7	guaranteed between component and tape
Δp	component alignment	0.0	±1.3	
Δh	component alignment	0.0	±2.0	
W	tape width	18.0	+1.0/–0.5	
W_0	hold down tape width	≥12.5		
W_1	hole position	9.0	±0.5	
W_2	hold down tape position	≤3.0		
H	height between component and tape centre	18 or 20.0	+2.0/–0.0	straight lead version
H_0	lead-wire flange height	16.0 or 18.25	±0.5	flanged and kinked lead versions
D_0	feed hole diameter	4.0	±0.2	
t	total tape thickness	≤1.4		with cardboard tape 0.5 ±0.1 mm

Table 3 Varistors on tape on reel

TYPE	2322 592 ..... Ø7 mm 14 V to 460 V	2322 593 ..... Ø9 mm 14 V to 460 V	2322 594 ..... Ø13.5 mm 14 V to 550 V	2322 595 ..... Ø17 mm 14 V to 460 V	2322 595 ..... Ø17 mm 510 V to 550 V
Straight leads; H = 18.0 or 20 mm; see Figs 5 and 6	0...6	0...6	0...6	0...6	0...6
Straight leads with flange; H_0 = 16 mm; see Fig.7	1...6	1...6	–	–	–
Straight leads with flange; H_0 = 18.25 mm; see Fig.7	2...6	2...6	–	–	–
Kinked leads; H_0 = 18.25 mm; see Fig.9	3...6	3...6	3...6	3...6	3...6
Kinked leads; H_0 = 16 mm; see Fig.8	8...6	8...6	8...6	8...6	8...6
Package quantities	3000	3000	1500	1500	1200

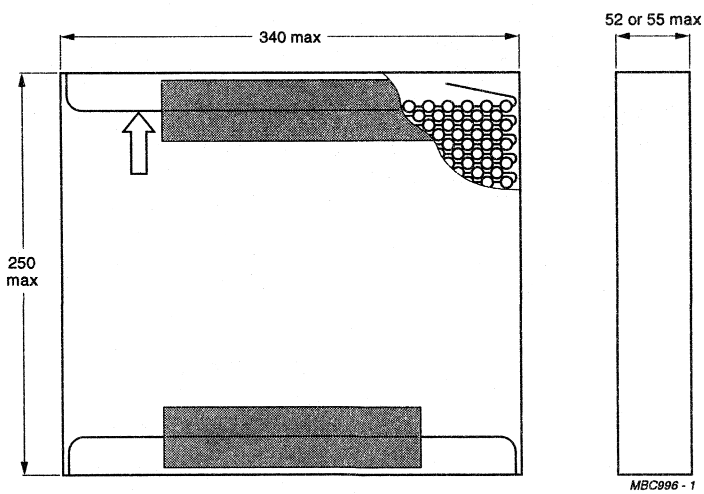


Dimensions in mm.

Fig.10 Dimensions of reels.

Table 4 Varistors on tape in ammopack

TYPE	2322 592 ..... ∅7 mm 14 V to 460 V	2322 593 ..... ∅9 mm 14 V to 460 V	2322 594 ..... ∅13.5 mm 14 V to 550 V	2322 595 ..... ∅17 mm 14 V to 550 V
Straight leads; H = 18 or 20 mm; see Figs 5 and 6	0...7	0...7	0...7	0...7
Straight leads with flange; H_0 = 16 mm; see Fig.7	1...7	1...7	–	–
Straight leads with flange; H_0 = 18.25 mm; see Fig.7	2...7	2...7	–	–
Kinked leads; H_0 = 18.25 mm; see Fig.9	3...7	3...7	3...7	3...7
Kinked leads; H_0 = 16 mm; see Fig.8	8...7	8...7	8...7	8...7
Package quantities				
14 to 175 V	1500	1500	750	750
230 to 460 V	1000	1000	–	–
230 to 300 V	–	–	600	600
320 to 550 V	–	–	500	500



Dimensions in mm.

Fig.11 Dimensions of ammopack.

Table 5 Varistors in bulk

TYPE	**2322 592 .....** **∅7 mm** **14 V to 460 V**	**2322 593 .....** **∅9 mm** **14 V to 460 V**	**2322 594 .....** **∅13.5 mm** **14 V to 550 V**	**2322 595 .....** **∅17 mm** **14 V to 550 V**
Straight leads; see Fig.1	5...6	5...6	5...6	5...6
Straight leads with flange; see Fig.2	7...6	7...6	–	–
Kinked leads; see Fig.3	6...6	6...6	6...6	6...6
Package quantities	250	250	250	100 and 250

ELECTRICAL CHARACTERISTICS

Table 6 Electrical data

PARAMETER	VALUE	UNIT
Maximum continuous voltage:		
RMS	14 to 550	V
DC	18 to 745	V
Maximum non-repetitive transient current (I_{nrp}) (8 × 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
Thermal resistance:		
2322 592	≈80	K/W
2322 593	≈70	K/W
2322 594	≈60	K/W
2322 595	≈50	K/W
Maximum dissipation:		
2322 592	100	mW
2322 593	250	mW
2322 594	400	mW
2322 595	600	mW
Temperature coefficient of voltage at 1 mA maximum	−0.065	%/K
Insulation voltage	2500	V
Climatic category	40/085/56	

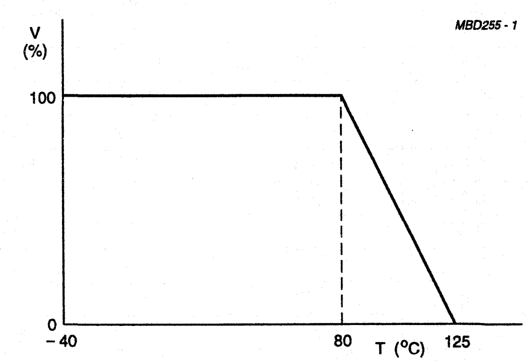


Fig.12 Derating curve.

Table 7 Electrical data and ordering information
Replace last digit of catalogue number with a '7' for ordering on tape in ammopack.

MAXIMUM CONTINUOUS VOLTAGE		VOLTAGE[(2)] at 1 mA	MAXIMUM VOLTAGE at STATED CURRENT		MAXIMUM ENERGY[(3)] (10 × 1000 μs)	MAXIMUM NON-REP. TRANSIENT CURRENT[(4)] I_{nrp} (8 × 20 μs)	TYPICAL CAPACITANCE at 1 kHz	CATALOGUE NUMBERS
RMS[(1)] (V)	DC (V)	(V)	V (V)	I (A)	(J)	(A)	(pF)	2322 ... .
14	18	22	48	1.0	0.5	100	1300	592 .1406[(5)]
			43	2.5	1.7	250	2800	593 .1406[(5)]
			43	5.0	4.3	500	6000	594 .1406[(5)]
			43	10.0	5.4	1000	15000	595 .1406[(5)]
17	22	27	60	1.0	0.7	100	1050	592 .1706[(5)]
			53	2.5	2.0	250	2000	593 .1706[(5)]
			53	5.0	5.3	500	4000	594 .1706[(5)]
			53	10.0	6.9	1000	10000	595 .1706[(5)]
20	26	33	73	1.0	0.8	100	900	592 .2006[(5)]
			65	2.5	2.5	250	1500	593 .2006[(5)]
			65	5.0	6.5	500	3000	594 .2006[(5)]
			65	10.0	8.8	1000	7500	595 .2006[(5)]
25	31	39	86	1.0	0.9	100	500	592 .2506[(5)]
			77	2.5	3.0	250	1350	593 .2506[(5)]
			77	5.0	7.7	500	2600	594 .2506[(5)]
			77	10.0	9.4	1000	6500	595 .2506[(5)]
30	38	47	96	1.0	1.1	100	700	592 .3006[(6)]
			93	2.5	3.6	250	1600	593 .3006[(6)]
			93	5.0	9.2	500	2700	594 .3006[(6)]
			90	10.0	12.0	1000	6000	595 .3006[(6)]
35	45	56	123	1.0	1.4	100	560	592 .3506[(6)]
			115	2.5	4.4	250	1300	593 .3506[(6)]
			110	5.0	11.0	500	2200	594 .3506[(6)]
			105	10.0	14.0	1000	4800	595 .3506[(6)]
40	56	68	145	1.0	1.6	100	460	592 .4006[(6)]
			135	2.5	5.2	250	1000	593 .4006[(6)]
			130	5.0	13.0	500	1800	594 .4006[(6)]
			130	10.0	17.0	1000	3800	595 .4006[(6)]
50	65	82	145	5.0	2.6	400	370	592 .5006[(6)]
			140	10.0	7.0	1200	900	593 .5006[(6)]
			140	25.0	12.0	2500	1500	594 .5006[(6)]
			140	50.0	21.0	4500	3100	595 .5006[(6)]

MAXIMUM CONTINUOUS VOLTAGE		VOLTAGE[(2)] at 1 mA	MAXIMUM VOLTAGE at STATED CURRENT		MAXIMUM ENERGY[(3)] (10 × 1000 μs)	MAXIMUM NON-REP. TRANSIENT CURRENT[(4)] I_{nrp} (8 × 20 μs)	TYPICAL CAPACITANCE at 1 kHz	CATALOGUE NUMBERS
RMS[(1)] (V)	DC (V)	(V)	V (V)	I (A)	(J)	(A)	(pF)	2322 ... .
60	85	100	165	5.0	2.9	400	290	592 .6006[(6)]
			165	10.0	8.3	1200	700	593 .6006[(6)]
			165	25.0	15.0	2500	1200	594 .6006[(6)]
			165	50.0	24.0	4500	2300	595 .6006[(6)]
75	100	120	190	5.0	3.4	400	240	592 .7506[(6)]
			200	10.0	10.0	1200	530	593 .7506[(6)]
			200	25.0	18.0	2500	1000	594 .7506[(6)]
			200	50.0	29.0	4500	1900	595 .7506[(6)]
95	125	150	230	5.0	4.1	400	180	592 .9506[(6)]
			250	10.0	13.0	1200	450	593 .9506[(6)]
			250	25.0	22.0	2500	800	594 .9506[(6)]
			250	50.0	37.0	4500	1500	595 .9506[(6)]
130	170	205	310	5.0	5.5	400	130	592 .1316[(6)]
			340	10.0	17.0	1200	320	593 .1316[(6)]
			340	25.0	30.0	2500	580	594 .1316[(6)]
			340	50.0	56.0	4500	1050	595 .1316[(6)]
140	180	220	350	5.0	6.3	400	120	592 .1416[(6)]
			370	10.0	21.0	1200	290	593 .1416[(6)]
			370	25.0	33.0	2500	540	594 .1416[(6)]
			370	50.0	57.0	4500	950	595 .1416[(6)]
150	200	240	395	5.0	7.1	400	110	592 .1516[(6)]
			400	10.0	20.0	1200	270	593 .1516[(6)]
			400	25.0	36.0	2500	490	594 .1516[(6)]
			400	50.0	59.0	4500	850	595 .1516[(6)]
175	225	275	410	5.0	7.3	400	90	592 .1716[(6)]
			455	10.0	23.0	1200	230	593 .1716[(6)]
			455	25.0	41.0	2500	430	594 .1716[(6)]
			455	50.0	67.0	4500	750	595 .1716[(6)]
230	300	360	560	5.0	10.0	400	70	592 .2316[(6)]
			600	10.0	30.0	1200	170	593 .2316[(6)]
			600	25.0	54.0	2500	320	594 .2316[(6)]
			600	50.0	88.0	4500	540	595 .2316[(6)]

MAXIMUM CONTINUOUS VOLTAGE		VOLTAGE[(2)] at 1 mA	MAXIMUM VOLTAGE at STATED CURRENT		MAXIMUM ENERGY[(3)] (10 × 1000 μs)	MAXIMUM NON-REP. TRANSIENT CURRENT[(4)] I_{nrp} (8 × 20 μs)	TYPICAL CAPACITANCE at 1 kHz	CATALOGUE NUMBERS
RMS[(1)] (V)	DC (V)	(V)	V (V)	I (A)	(J)	(A)	(pF)	2322 ... .
250	320	390	600	5.0	11.0	400	60	592 .2516[(6)]
			650	10.0	33.0	1200	160	593 .2516[(6)]
			650	25.0	58.0	2500	300	594 .2516[(6)]
			650	50.0	96.0	4500	480	595 .2516[(6)]
275	350	430	695	5.0	12.0	400	55	592 .2716[(6)]
			710	10.0	36.0	1200	140	593 .2716[(6)]
			710	25.0	63.0	2500	270	594 .2716[(6)]
			710	50.0	104.0	4500	440	595 .2716[(6)]
300	385	470	750	5.0	13.0	400	50	592 .3016[(6)]
			800	10.0	40.0	1200	130	593 .3016[(6)]
			800	25.0	71.0	2500	240	594 .3016[(6)]
			800	50.0	117.0	4500	400	595 .3016[(6)]
320	420	510	800	5.0	15.0	400	45	592 .3216[(6)]
			850	10.0	44.0	1200	120	593 .3216[(6)]
			850	25.0	77.0	2500	220	594 .3216[(6)]
			850	50.0	120.0	4500	370	595 .3216[(6)]
385	505	620	1000	5.0	18.0	400	40	592 .3816[(6)]
			1025	10.0	51.0	1200	95	593 .3816[(6)]
			1025	25.0	67.0	2500	180	594 .3816[(6)]
			1025	50.0	110.0	4500	280	595 .3816[(6)]
420	560	680	1100	5.0	20.0	400	35	592 .4216[(6)]
			1120	10.0	56.0	1200	85	593 .4216[(6)]
			1120	25.0	73.0	2500	165	594 .4216[(6)]
			1120	50.0	120.0	4500	250	595 .4216[(6)]
460	615	750	1200	5.0	21.0	400	30	592 .4616[(6)]
			1240	10.0	63.0	1200	75	593 .4616[(6)]
			1240	25.0	82.0	2500	150	594 .4616[(6)]
			1240	50.0	135.0	4500	225	595 .4616[(6)]
510	670	820	1355	25.0	89.0	2500	135	594 .5116[(6)]
			1355	50.0	145.0	4500	220	595 .5116[(6)]
550	745	910	1500	25.0	98.0	2500	120	594 .5516[(6)]
			1500	50.0	160.0	4500	180	595 .5516[(6)]

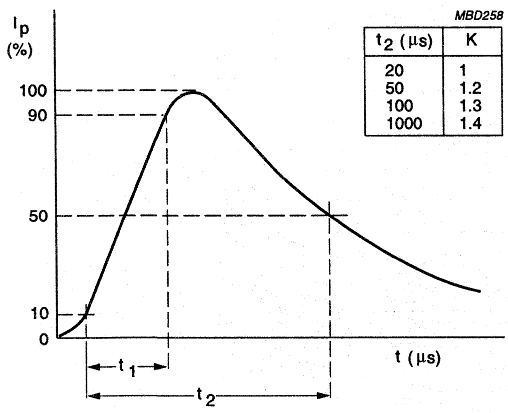
Notes to Table 7

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 *"paragraph 4.3 of CECC specification 42000"*.
3. High energy surges are generally of longer duration. The maximum energy for one pulse of 10 × 1 000 μs is given as a reference for longer duration pulses. This pulse can be characterised by peak current (I_p) and pulse 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 varistor is determined by the formula:

   $E = K \times V_p \times I_p \times t_2$

   where:

   K is dependent on the value of t_2 when the value of t_1 is between 8 μs and 10 μs; see Fig.13.
4. A current wave of 8 × 20 μs (requirement of *"paragraph B.2.10.1 of CECC specification 42000"*) is used as a standard for pulse current and clamping voltage ratings. The maximum non-repetitive transient current is given for one pulse applied during the life of the component.
5. Only available on request
6. CECC approved types.



t_2 (μs)	K
20	1
50	1.2
100	1.3
1000	1.4

Fig.13 Peak current as a function of pulse width.

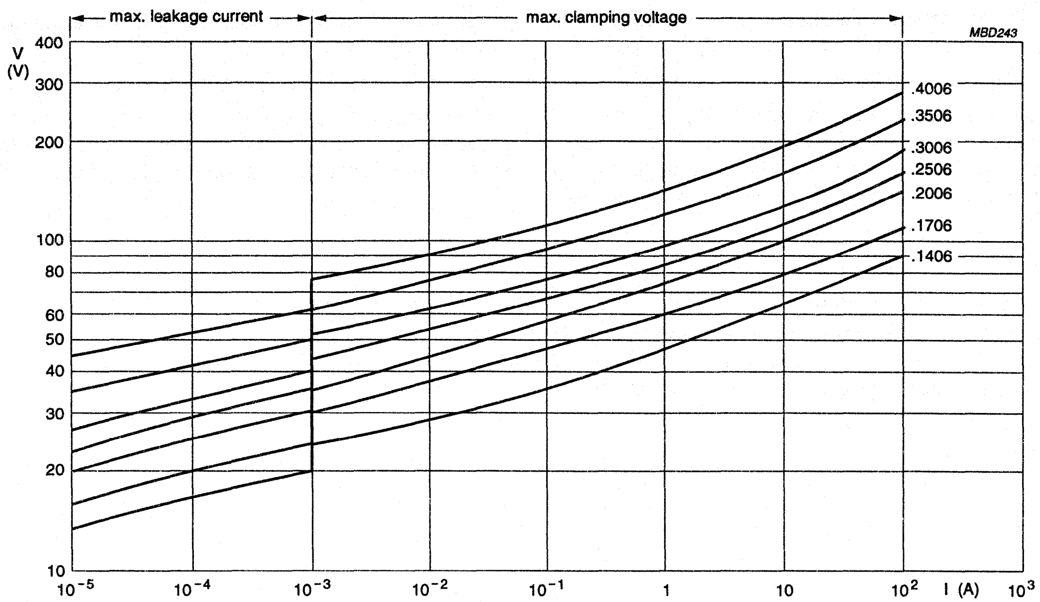


Fig.14 V/I characteristics, 14 V to 40 V (RMS); 2322 592 series.

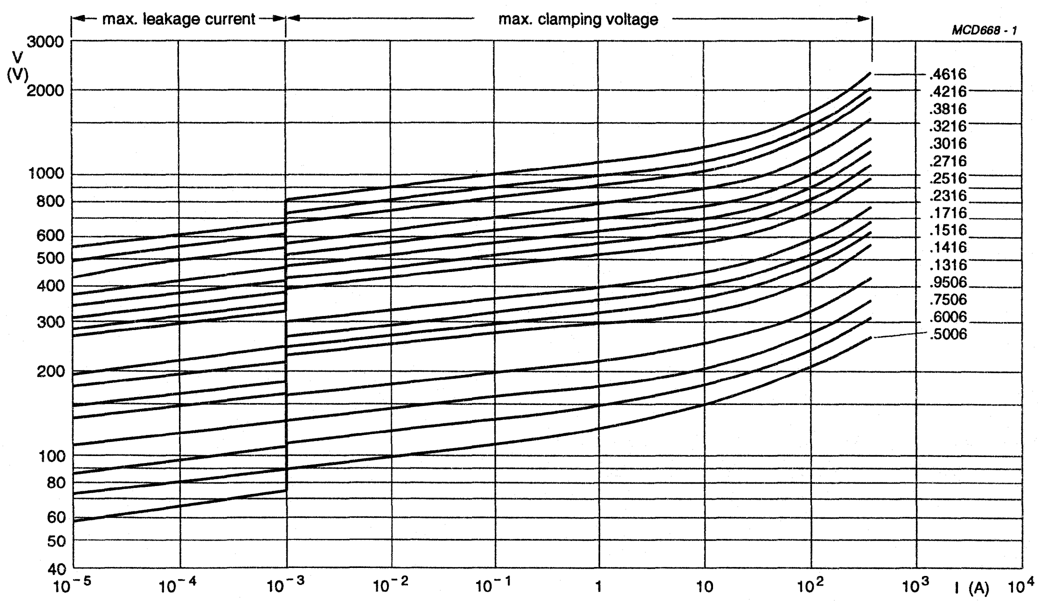


Fig.15 V/I characteristics, 50 V to 460 V (RMS); 2322 592 series.

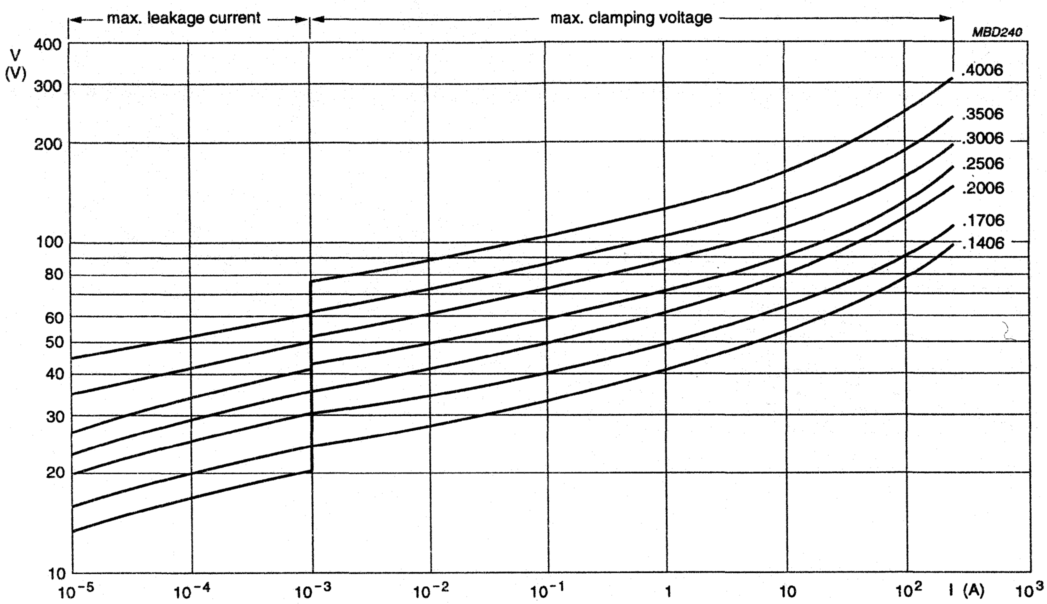


Fig.16 V/I characteristics, 14 V to 40 V (RMS); 2322 593 series.

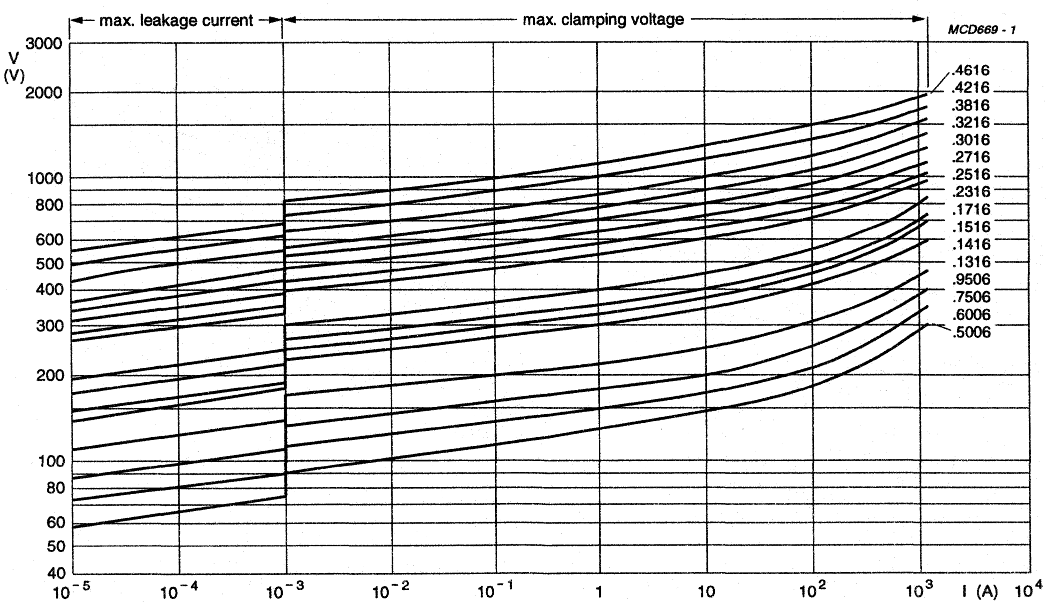


Fig.17 V/I characteristics, 50 V to 460 V (RMS); 2322 593 series.

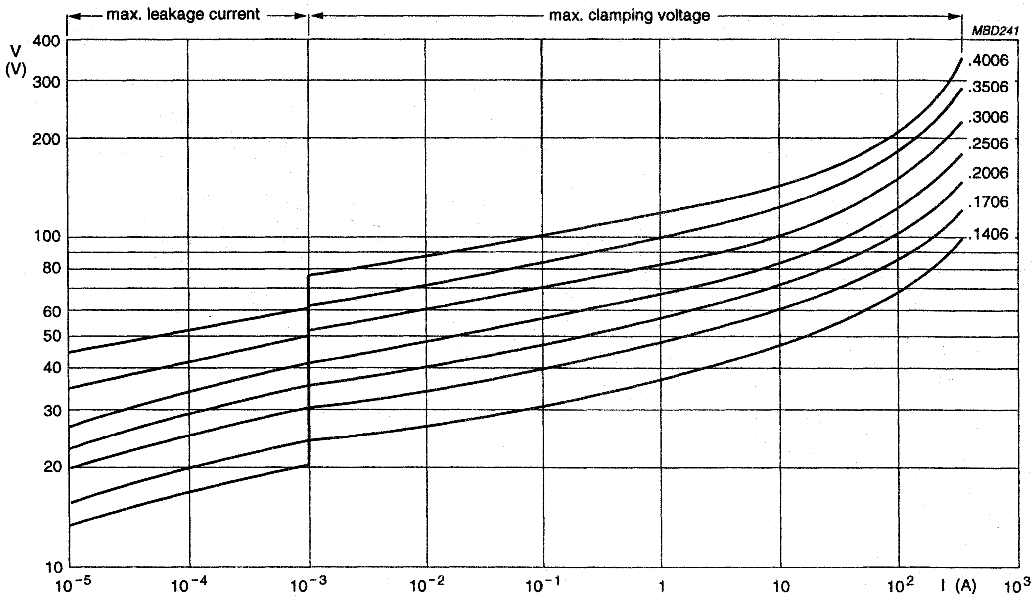


Fig.18 V/I characteristics, 14 V to 40 V (RMS); 2322 594 series.

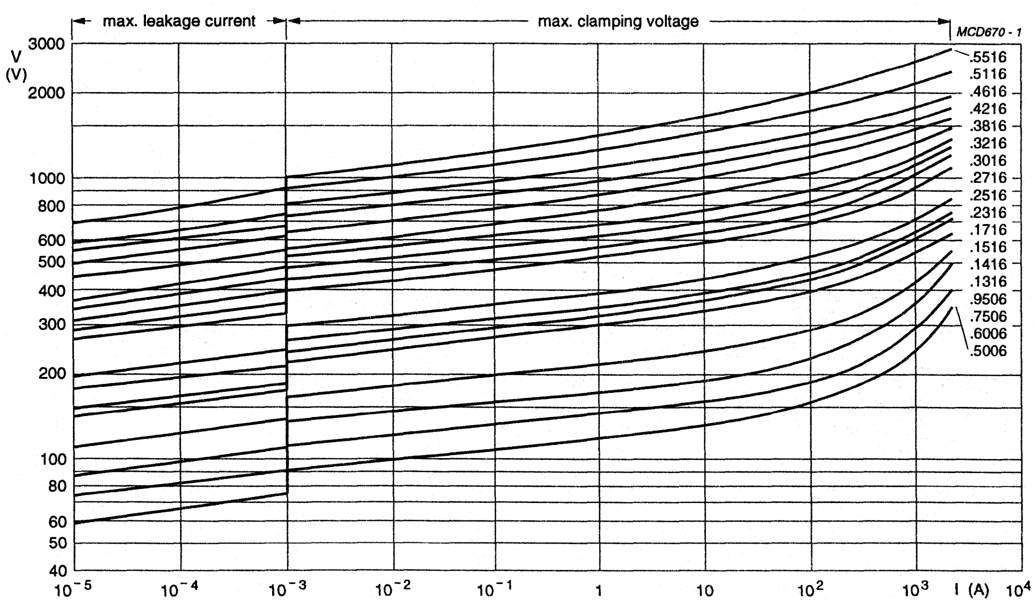


Fig.19 V/I characteristics, 50 V to 550 V (RMS); 2322 594 series.

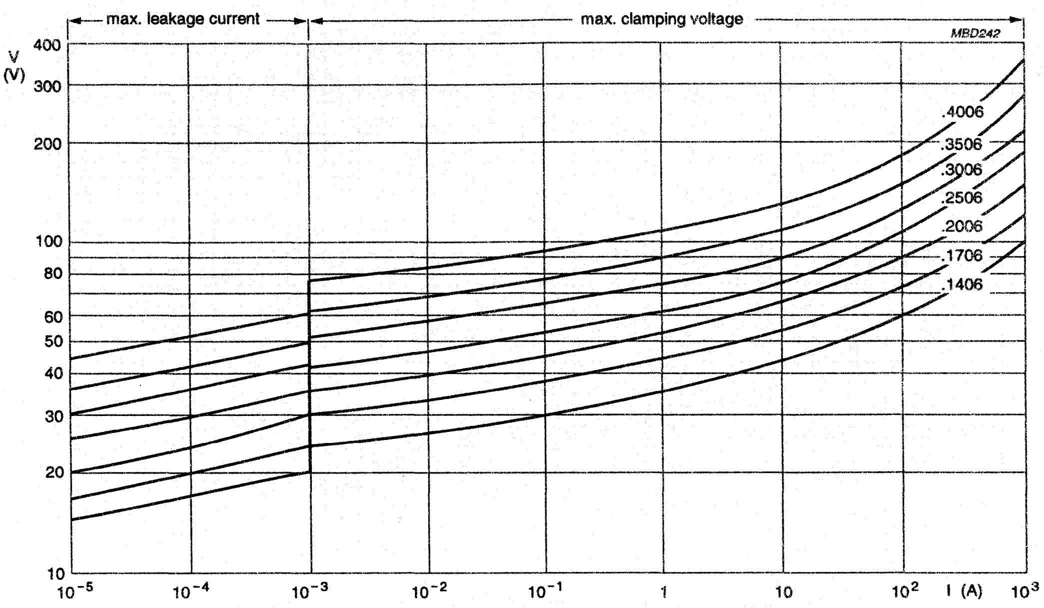


Fig.20 V/I characteristics, 14 V to 40 V (RMS); 2322 595 series.

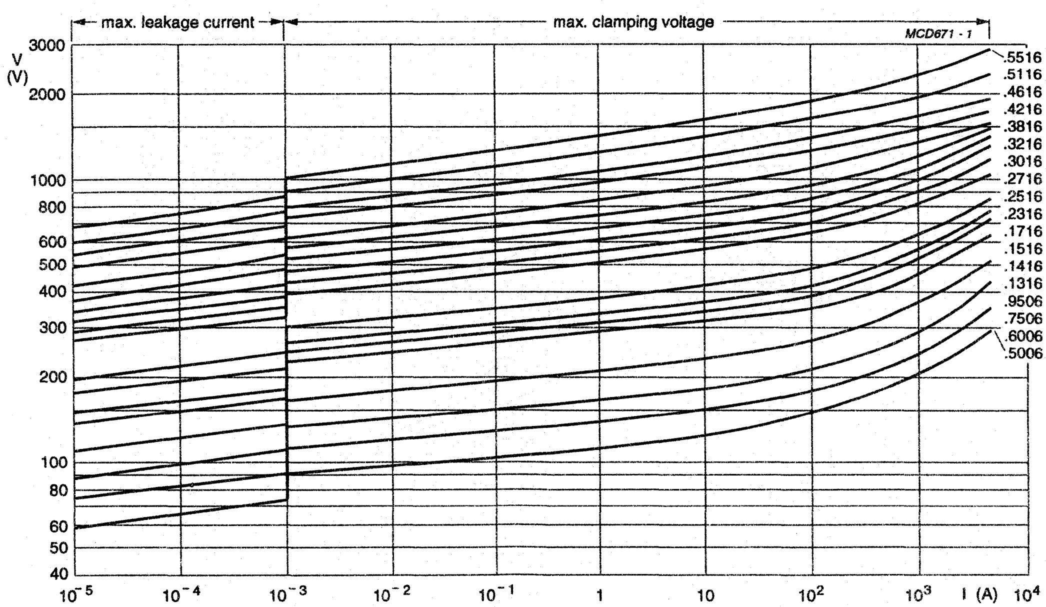


Fig.21 V/I characteristics, 50 V to 550 V (RMS); 2322 595 series.

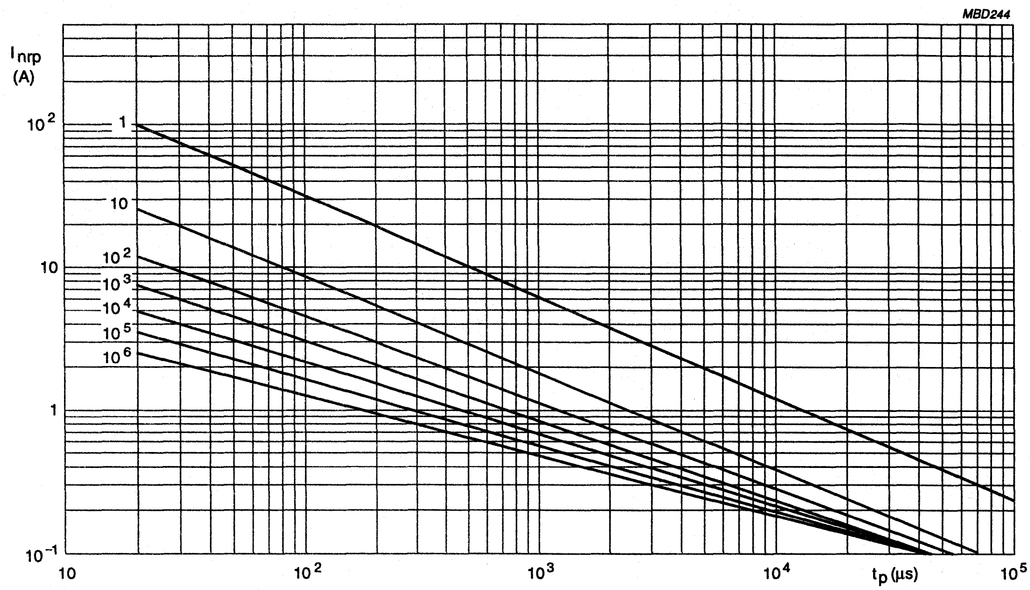


Fig.22 Maximum applicable transient current as a function of pulse duration, 14 V to 40 V (RMS); 2322 592 series.

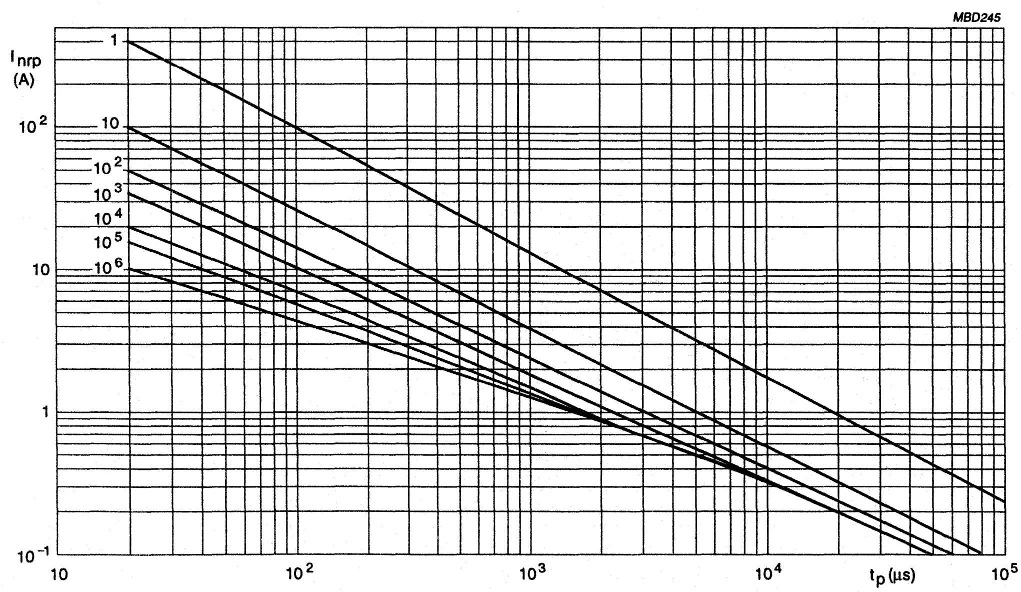


Fig.23 Maximum applicable transient current as a function of pulse duration, 50 V to 460 V (RMS); 2322 592 series.

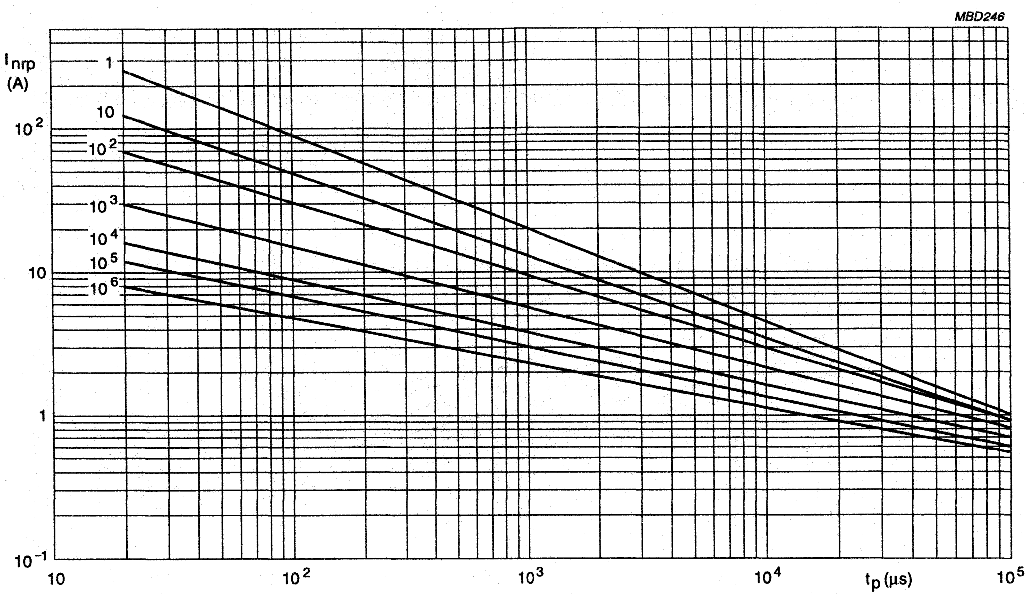


Fig.24 Maximum applicable transient current as a function of pulse duration, 14 V to 40 V (RMS); 2322 593 series.

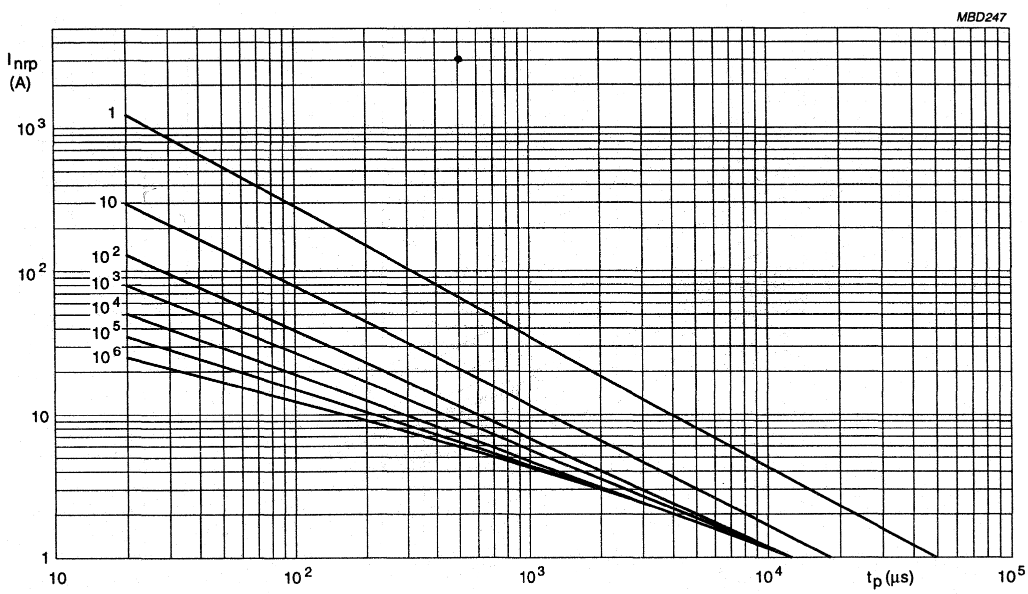


Fig.25 Maximum applicable transient current as a function of pulse duration, 50 V to 460 V (RMS); 2322 593 series.

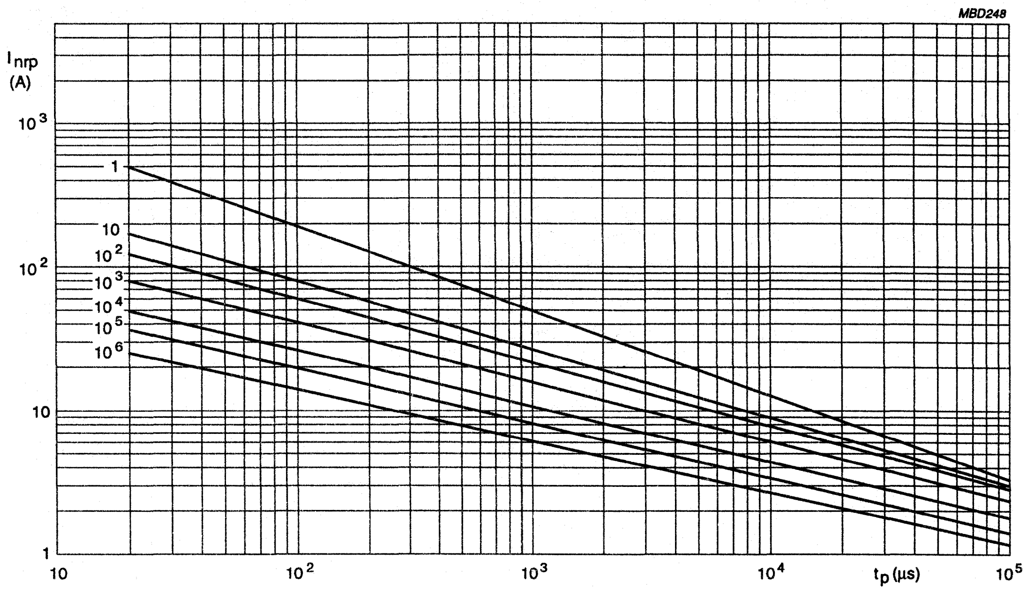


Fig.26 Maximum applicable transient current as a function of pulse duration, 14 V to 40 V (RMS); 2322 594 series.

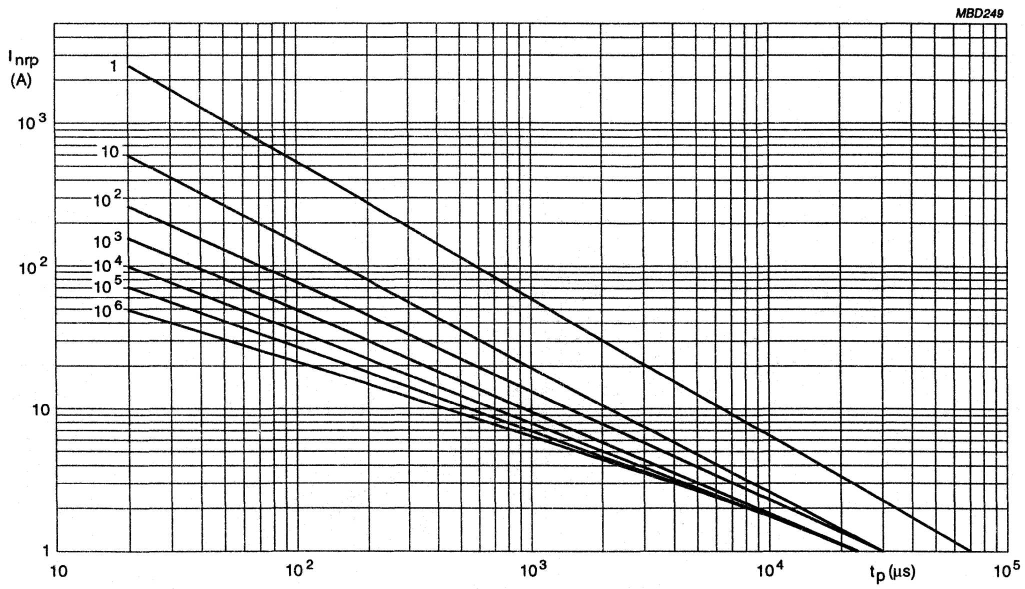


Fig.27 Maximum applicable transient current as a function of pulse duration, 50 V to 320 V (RMS); 2322 594 series.

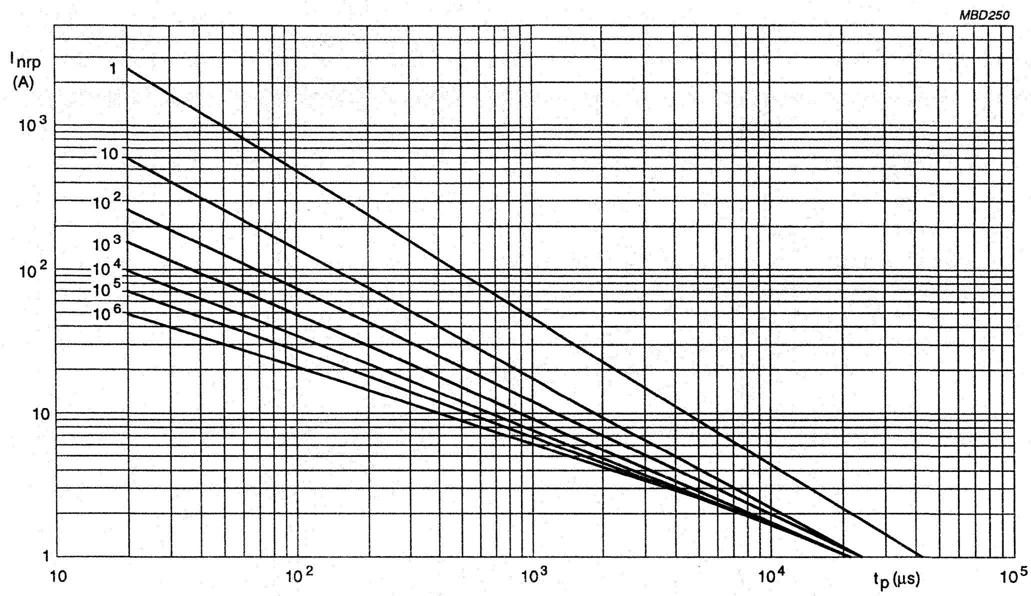


Fig.28 Maximum applicable transient current as a function of pulse duration, 385 V to 550 V (RMS); 2322 594 series.

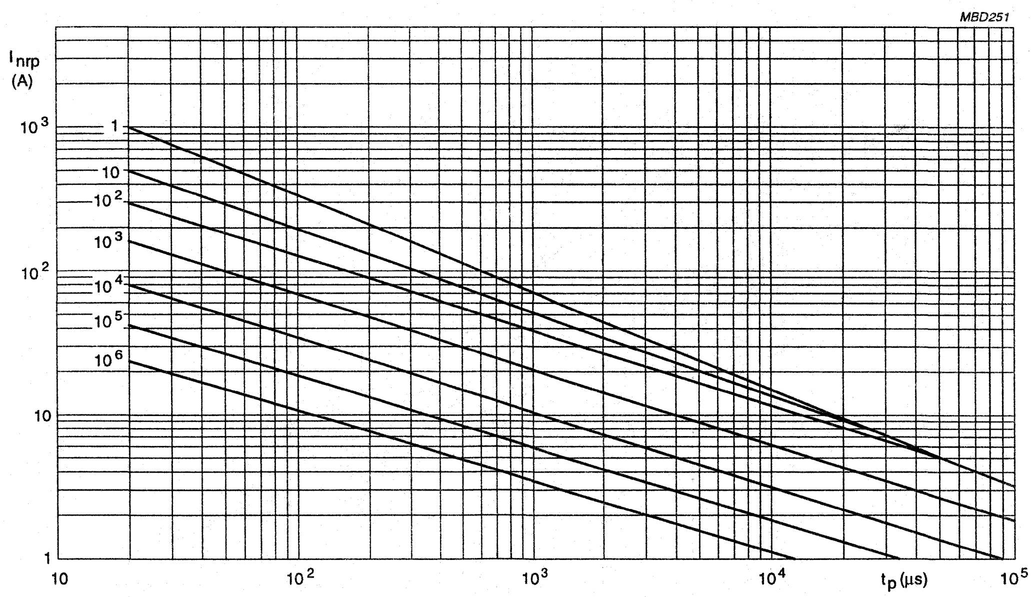


Fig.29 Maximum applicable transient current as a function of pulse duration, 14 V to 40 V (RMS); 2322 595 series.

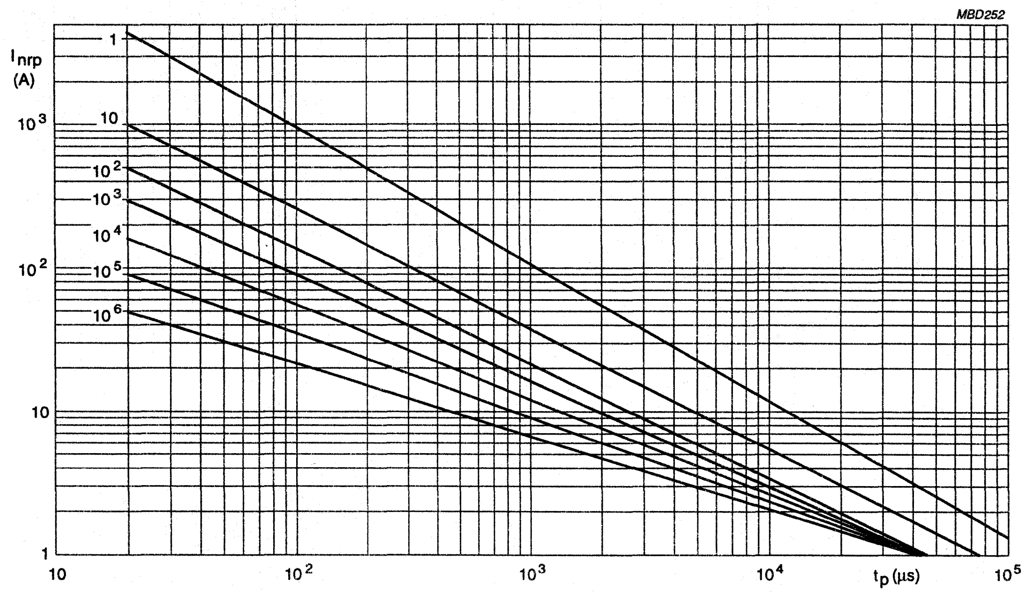


Fig.30 Maximum applicable transient current as a function of pulse duration, 50 V to 320 V (RMS); 2322 595 series.

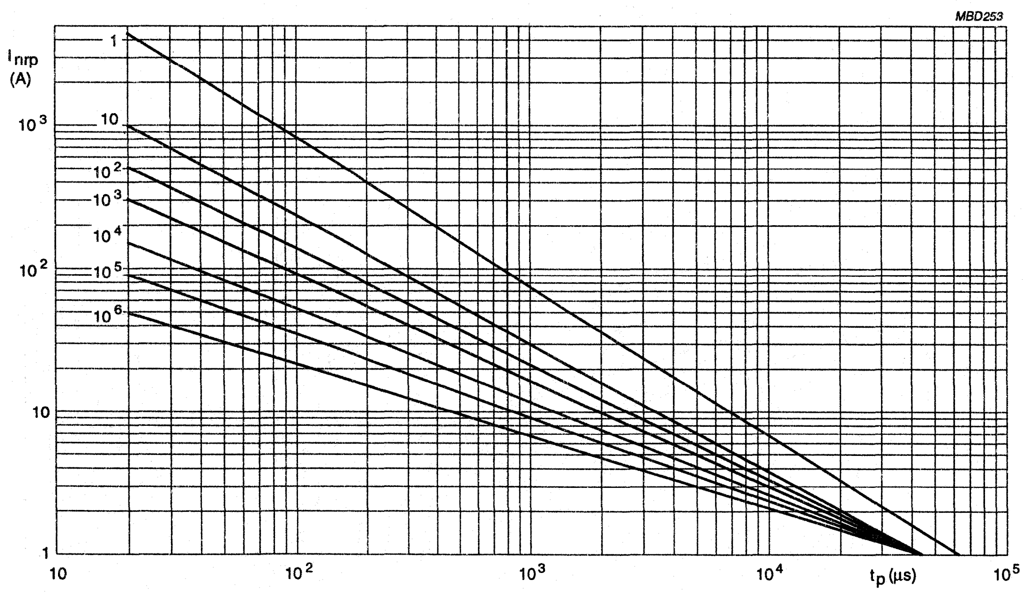


Fig.31 Maximum applicable transient current as a function of pulse duration, 385 V to 550 V (RMS); 2322 595 series.

HUMIDITY SENSOR

Humidity sensor 2322 691 90001

APPLICATIONS

- 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 which fit printed-circuit 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 incidental water condensation on the sensor foil. It should not be exposed to either acetone or chlorine vapours.

QUICK REFERENCE DATA

PARAMETER	VALUE	UNIT
Humidity range (RH)	10 to 90	%
Capacitance at +25 °C; 43% RH; 100 kHz	122 ±15%	pF
Sensitivity between 12 and 75% RH	0.4 ±0.05	pF/%RH
Frequency	1 to 1000	kHz
Maximum AC or DC voltage	15	V
Storage humidity range (RH)	0 to 100	%
Ambient temperature range:		
operating	0 to +85	°C
storage	−25 to +85	°C
Drop test:		
height of free fall	1	m
Mass	≈1.3	g

Humidity sensor 2322 691 90001

MECHANICAL DATA

Marking

PHILIPS H1.

Mounting

The device can be soldered directly on to a printed-circuit board or fastened with 3 mm bolts.

Soldering

Solderability: ≤240 °C; ≤4 s.

Resistance to heat: ≤240 °C; ≤4 s.

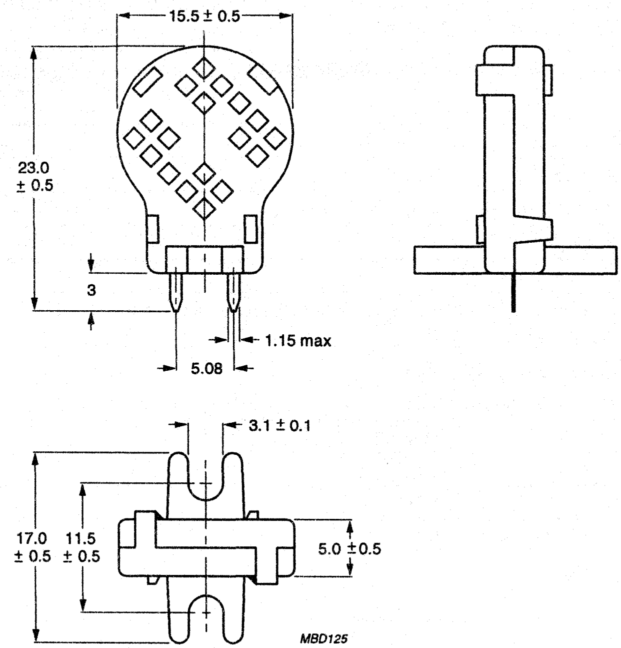
Robustness of terminations

Tensile strength: 10 N.

QUALITY LEVEL

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

- Inoperatives: 0.25%
- Electrical: 1%
- Mechanical: 1.5%.



Dimensions in mm.

Fig.1 Component outline.

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, measurements are in accordance with *"IEC publication 539"*. Stability is in accordance with *"CECC 43000"* and *"IEC 68-2"*.

PARAMETER	VALUE	UNIT
Humidity range (RH)	10 to 90	%
Capacitance at +25 °C; 43% RH; 100 kHz	122 ±15%	pF
Tan δ at +25 °C; 100 kHz; 43% RH	≤0.035	
Sensitivity between 12 and 75% RH	0.4 ±0.05	pF/%RH
Frequency range	1 to 1000	kHz
Temperature dependence	0.1	%
Response time in minutes (to 90% of indicated RH change at +25 °C, in circulating air):		
between 10 and 43% RH	<3	
between 43 and 90% RH	<5	
Hysteresis (for RH excursion of 10 to 90 to 10%)	≈3	%
Maximum AC or DC voltage	15	V
Storage humidity range (RH)	0 to 100	%
Ambient temperature range:		
operating	0 to +85	°C
storage	−25 to +85	°C
Mass	≈1.3	g

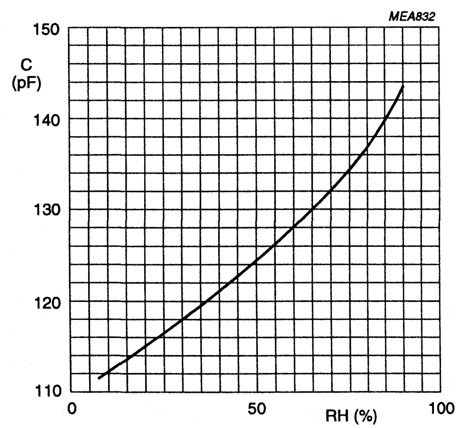


Fig.2 Typical capacitance as a function of relative humidity.

DATA HANDBOOK SYSTEM

Data handbook system

DATA HANDBOOK SYSTEM

Philips Components data handbooks are available for selected product ranges and contain all relevant data available at the time of publication and each is revised and updated regularly.

Loose data sheets are sent to subscribers to keep them up-to-date on additions or alterations made during the lifetime of each edition.

Our data handbook titles are listed here.

Display components

Book	*Title*
DC01	Colour TV Picture Tubes and Assemblies Colour Monitor Tubes
DC02	Monochrome Monitor Tubes and Deflection Units
DC03	Television Tuners, Coaxial Aerial Input Assemblies
DC05	Flyback Transformers, Mains Transformers and General-purpose FXC Assemblies

Magnetic products

MA01	Soft Ferrites
MA03	Piezoelectric Ceramics and Specialty Ferrites
MA04	Dry-reed Switches

Passive components

PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers
PA04	Variable Capacitors
PA05	Film Capacitors
PA06	Ceramic Capacitors
PA07	Quartz Crystals for Special and Industrial Applications
PA08	Fixed Resistors
PA10	Quartz Crystals for Automotive and Standard Applications
PA11	Quartz Oscillators

Professional components

PC04	Photo Multipliers
PC05	Plumbicon Camera Tubes and Accessories
PC07	Vidicon and Newvicon Camera Tubes and Deflection Units
PC08	Image Intensifiers
PC12	Electron Multipliers

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Data handbook system

OVERVIEW OF PHILIPS SEMICONDUCTORS DATA HANDBOOKS

Our sister product division, Philips Semiconductors, also has a comprehensive data handbook system to support their products. Their data handbook titles are listed here.

Integrated circuits

Book	*Title*
IC01	Semiconductors for Radio and Audio Systems
IC02	Semiconductors for Television and Video Systems
IC03	Semiconductors for Telecom Systems
IC04	CMOS HE4000B Logic Family
IC06	High-speed CMOS Logic Family
IC11	General-purpose/Linear ICs
IC12	I[2]C Peripherals
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	CMOS Integrated Circuits for Clocks and Watches
IC17	RF/Wireless Communications
IC18	Semiconductors for In-car Electronics
IC19	ICs for Data Communications
IC20	80C51-based 8-bit Microcontrollers
IC22	Desktop Video
IC23	QUBiC Advanced BiCMOS Interface Logic ABT MULTIBYTE™
IC24	Low Voltage CMOS & BiCMOS Logic

Discrete semiconductors

SC01	Diodes
SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small-signal Transistors
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors
SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC13	PowerMOS Transistors including TOPFETs and IGBTs
SC14	RF Wideband Transistors, Video Transistors and Modules

Discrete semiconductors (continued)

SC15	Microwave Transistors
SC16	Wideband Hybrid IC Modules
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PC01	High-power Klystrons and Accessories
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