INTERNATIONAL STANDARD

IEC 60539-1

QC 430000

First edition
2002-02

Directly heated negative temperature coefficient thermistors –

Part 1: Generic specification

Thermistors à coefficient de température négatif à chauffage direct –

Partie 1: Spécification générique

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIRECTLY HEATED NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS –

Part 1: Generic specification

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60539-1 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This edition cancels and replaces the first edition of IEC 60539 published in 1976.

The text of this standard is based on the following documents:

FDIS	Report on voting
40/1193/FDIS	40/1249/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Annexes A, B and C form an integral part of this standard.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

DIRECTLY HEATED NEGATIVE TEMPERATURE COEFFICIENT THERMISTORS –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60539 is applicable to directly heated negative temperature coefficient thermistors, typically made from transition metal oxide materials with semiconducting properties.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purpose.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60539. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60539 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

NOTE In the case of IEC 60068 standards, use the referenced edition.

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IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

IEC 60062:1992, *Marking codes for resistors and capacitors*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
Amendment 1 (1992)

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry Heat*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-3:1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state* (incorporating Amendment 1 (1984))

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-13:1983, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*
Amendment 1 (1986)

IEC 60068-2-17:1994, *Environmental testing – Part 2: Tests – Test Q: Sealing*

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2 (1987)

IEC 60068-2-21:1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*
Amendment 2 (1991)
Amendment 3 (1992)

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*
Amendment 1 (1985)

IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*
Amendment 1 (1993)

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IEC 60068-2-52:1984, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-58:1989, *Environmental testing – Part 2: Tests – Test Td: Solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

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IEC 60249-2-4:1987, *Base materials for printed circuits – Part 2: Specifications – Specification No. 4: Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade*
Amendment 3 (1993)
Amendment 4 (1994)

IEC 60294:1969, *Measurement of the dimensions of a cylindrical component having two axial terminations*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60617 (all parts), *Graphical symbols for diagrams*

IEC 60717:1981, *Method for determination of the space required by capacitors and resistors with unidirectional terminations*

IEC 61760-1:1998, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

IEC QC 001002-3:1998, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of procedure – Part 3: Approval procedures*

ISO 1 000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

2 Technical data

2.1 Units, symbols and terminology

Units, graphical symbols, letter symbols and terminology should, whenever possible, be taken from the following publications:

– IEC 60027
– IEC 60050
– IEC 60617
– ISO 1000

When further items are required they should be derived in accordance with the principles of the publications listed above.

2.2 Definitions

For the purpose of this part of IEC 60539, the following definitions apply:

2.2.1
type
products having similar design features manufactured by the same techniques and falling within the manufacturer's usual range of ratings for these products

NOTE 1 Mounting accessories are ignored, provided they have no significant effect on the test results.

NOTE 2 Ratings cover the combination of:
– electrical ratings;
– sizes;
– climatic category.

NOTE 3 The limits of the range of ratings shall be given in the detail specification.

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2.2.2
style
variation within a type having specific nominal dimensions and characteristics

2.2.3
thermistor
thermally sensitive semiconducting resistor whose primary function is to exhibit an important change in electrical resistance with a change in body temperature

2.2.4
negative temperature coefficient thermistor (NTC)
thermistor in which the resistance decreases with increasing temperature

2.2.5
directly heated negative temperature coefficient thermistor
it obtains its resistance variation by the changes of physical conditions such as current through the thermistor, ambient temperature, humidity, wind velocity, gas, etc.

2.2.6
indirectly heated negative temperature coefficient thermistor
it obtains its resistance variation primarily by the change of temperature of the thermistor, due to the change of a current through a separate heater which is in close contact with, but electrically insulated from, the thermistor element

NOTE Temperature of the thermistor can also be changed by the changes of physical conditions such as current through the thermistor element itself, ambient temperature, humidity, wind velocity, gas, etc.

2.2.7
positive temperature coefficient (PTC) thermistor (for information only)
thermistor in which the resistance increases with increasing temperature

2.2.8
thermistor with wire terminations
thermistor provided with wire terminations

2.2.9
thermistor without wire terminations
thermistor provided only with two metallized faces, to be used as electrical contacts

2.2.10
insulated thermistor
thermistor coated with materials such as resin, glass or ceramic, capable of meeting the requirements of the insulation resistance and voltage proof tests when specified in the test schedule

2.2.11
non-insulated thermistor
thermistor with or without coating materials for surfacing of elements but not intended to meet the requirements of the insulation resistance and voltage proof tests when specified in the test schedule

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2.2.12
surface mount thermistor
thermistor whose small dimensions and nature or shape of terminations make them suitable for use in hybrid circuits and on printed board

2.2.13
assembled thermistor (probe)
thermistor encapsulated in different materials such as tubes, plastic and metal housing and/or assembled with cables and/or connectors

2.2.14
thermistor for sensing
thermistor which responds to temperature changes and therefore is used for temperature sensing and control

2.2.15
inrush current limiting thermistor
thermistor which limits the inrush current just after switching on the power

2.2.16
residual resistance (only for inrush current limiting thermistors)
value of the d.c. resistance of a thermistor when its thermal stability is reached with the maximum current passing

2.2.17
maximum permissible capacitance (only for inrush current limiting thermistors)
maximum permissible capacitance value of a capacitor which can be connected to a thermistor under loading

2.2.18
zero-power resistance, R_T
value of the d.c. resistance of a thermistor, when measured at a specified temperature, under such conditions that the change in resistance due to the internal generation of heat is negligible with respect to the total error of measurement

2.2.19
rated zero-power resistance
nominal value at the standard reference temperature of 25 °C, unless otherwise specified

2.2.20
resistance-temperature characteristic
relationship between the zero-power resistance and the body temperature of a thermistor

The resistance law follows approximately the formula:

$$R = R_a \times e^{B\left(\frac{1}{T} - \frac{1}{T_a}\right)}$$

where

R is the zero-power resistance in ohms (Ω) at absolute temperature T in kelvins (K);

R_a is the zero-power resistance in ohms (Ω) at absolute temperature T_a in kelvins (K);

B is the thermal sensitivity index (see 2.2.22).

NOTE This formula is only applicable for representing the resistance variation over a restricted temperature range. For more precise representation of the R/T-curve, a resistance/temperature relation should be specified in tabulated form in the detail specification.

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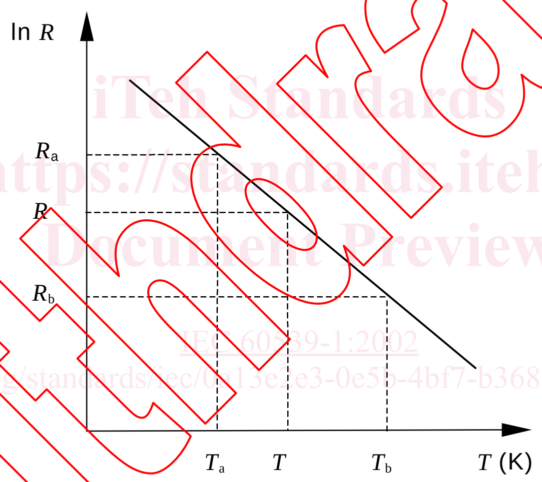

Figure 1 – Typical resistance-temperature characteristic for NTC thermistors

2.2.21
resistance ratio
ratio of the zero-power resistance of a thermistor measured at the reference temperature of

25 °C to that measured at 85 °C, or at such other pairs of temperatures as may be prescribed in the detail specification

2.2.22
***B*-value**
index of the thermal sensitivity expressed by the formula:

$$B = [(T_a \times T_b)/(T_b - T_a)] \times \ln(R_a/R_b)$$

or

$$B = 2{,}303 \times [(T_a \times T_b)/(T_b - T_a)] \times \log(R_a/R_b)$$

where

B is a constant in kelvins (K);

R_a is the zero-power resistance in ohms (Ω) at temperature T_a in kelvins (K);

R_b is the zero-power resistance in ohms (Ω) at temperature T_b in kelvins (K);

T_a = 298,15 K *);

T_b = 358,15 K *).

*)The values given above for T_a and T_b are the preferred values and are equivalent to +25 °C and +85 °C respectively.

NOTE Where the detail specification prescribes that the B-value shall be measured at other temperatures, the specified values (in kelvins) shall be used for T_a and T_b in the calculation in place of the preferred values and the B-value may be expressed by "$B_{a/b}$".

2.2.23
zero-power temperature coefficient of resistance, α_T
the ratio at a specified temperature (T) of the rate of change of zero-power resistance with temperature to the zero-power resistance of the thermistor, expressed by the formula:

$$\alpha_T = 1/R_T \times dR_T/dT \times 100$$

The value α_T can be approximately calculated by the formula:

$$\alpha_T = -B/T^2 \times 100$$

where

α_T is the zero-power temperature coefficient of resistance in %/K;

R_T is the zero-power resistance in ohms at temperature T in kelvins (K);

B is the index of the thermal sensitivity in kelvins (K).

2.2.24
category temperature range
range of ambient temperatures for which the thermistor has been designed to operate continuously at zero-power, defined by the temperature limits of the appropriate category

2.2.25
upper category temperature, θ_{max}
maximum ambient temperature for which a thermistor has been designed to operate continuously at zero-power

2.2.26
lower category temperature, θ_{min}
minimum ambient temperature for which a thermistor has been designed to operate continuously at zero-power

2.2.27
storage temperature range
range of ambient temperatures for which a thermistor can be stored continuously under no-load condition

2.2.28
decreased power dissipation curve (not for inrush current limiting thermistors)

relation between the ambient temperature and the maximum power dissipation $P_{max\theta}$, which is usually expressed as curve a or alternatively as curve b in figure 2

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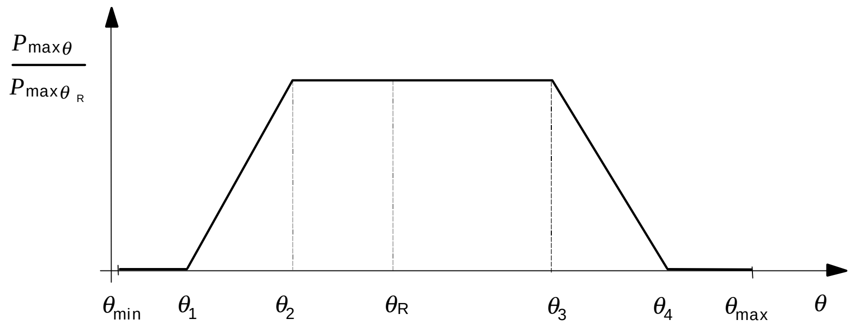
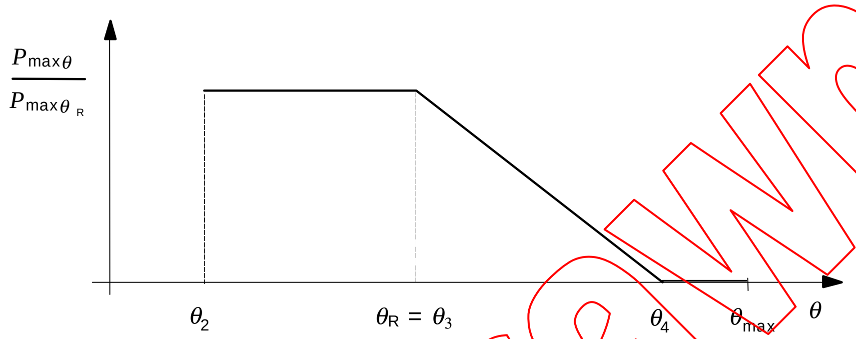


Curve a



Curve b

Figure 2 – Decreased power dissipation curve

2.2.29

maximum power dissipation at rated ambient temperature θ_R ($P_{\max\theta_R}$)

maximum value of the power dissipation which can be continuously applied to the thermistor at the rated ambient temperature θ_R (see curve a, $\theta_2 \leq \theta_R \leq \theta_3$ or curve b, $\theta_2 \leq \theta_R = \theta_3$ in figure 2)

The rated ambient temperature θ_R is the ambient temperature specified in the detail specification and is usually 25 °C.

2.2.30

maximum power dissipation at ambient temperature θ ($P_{\max\theta}$)

maximum value of the power dissipation which can be continuously applied to the thermistor at an ambient temperature θ

Curve a

The maximum power dissipation rises at a temperature θ_1 linearly to a temperature θ_2. Between temperature θ_2 and θ_3 the power dissipation is constant. When the temperature exceeds θ_3, the power dissipation must be decreased linearly to zero at a temperature θ_4.

The maximum power dissipation at ambient temperature θ in general is calculated as follows:

$$P_{\max\theta} = I_{\max\theta} \times U$$

where U is the voltage across the thermistor (for $I_{\max\theta}$, see 2.2.32).

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The maximum power dissipation can be expressed by the following formula:

$\theta_1 \leq \theta \leq \theta_2$: $$P_{\max.\theta} = P_{\max.\theta_R} \times \frac{\theta - \theta_1}{\theta_2 - \theta_1}$$

$\theta_3 \leq \theta \leq \theta_4$: $$P_{\max.\theta} = P_{\max.\theta_R} \times \frac{\theta_4 - \theta}{\theta_4 - \theta_3}$$

where

θ_R is the rated ambient temperature in Celsius (°C);

θ_1 is the temperature in Celsius (°C) specified in the detail specification below which zero-power shall be applied. θ_1 is equal to the lower category temperature $\theta_{min.}$(°C) or higher;

θ_2 is the lowest temperature at which $P_{max.\theta}$ can be applied. θ_2 = 0 °C, unless otherwise specified in the detail specification;

θ_3 is the maximum temperature at which $P_{max.\theta}$ can be applied. θ_3 = 55 °C, unless otherwise specified in the detail specification;

θ_4 is the temperature in Celsius (°C) specified in the detail specification, above which zero-power shall be applied. θ_4 is equal to, or lower than the upper category temperature $\theta_{max.}$ (°C).

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Curve b

The maximum power dissipation is constant between temperature θ_2 and θ_R. θ_2 = 0 °C, unless otherwise specified in the detail specification. When the temperature exceeds θ_R, the power dissipation must be decreased linearly to zero at a temperature θ_4.

The maximum power dissipation at ambient temperature θ in general is calculated as follows:

$$P_{\max\theta} = I_{\max\theta} \times U$$

where U is the voltage across the thermistor (for $I_{max.\theta}$, see 2.2.32).

The maximum power dissipation can be expressed by the following formula:

$\theta_R \leq \theta \leq \theta_4$: $$P_{\max\theta} = P_{\max\theta_R} \times \frac{\theta_4 - \theta}{\theta_4 - \theta_R}$$

where

θR is the rated ambient temperature in Celsius (°C). θR = 25 °C, unless otherwise specified in the detail specification;

θ4 is the temperature in Celsius (°C) specified in the detail specification, above which zero-power shall be applied. θ4 is equal to, or lower than the upper category temperature $\theta_{max.}$ (°C).

2.2.31

maximum current at ambient temperature of 25 °C (I_{max25}) (for inrush current limiting thermistors)

maximum value of current (d.c. or r.m.s. values for sine-shaped a.c.) which can be continuously applied to the thermistor at an ambient temperature of 25 °C (see curve c, $\theta_2 \leq$ 25 °C $\leq \theta_3$ or curve d, $\theta_2 \leq \theta_R = \theta_3$ in figure 3)

NOTE The maximum power dissipation at ambient temperature of 25 °C (P_{max25}) is calculated by:

$P_{max25} = I_{max25} \times U$, where U is the voltage drop across the thermistor.