INTERNATIONAL STANDARD

IEC 60738-1

QC 440000

Second edition
1998-11

**Thermistors –
Directly heated positive step-function temperature coefficient –**

**Part 1:
Generic specification**

Thermistances à basculement à coefficient de température positif à chauffage direct –

*Partie 1:
Spécification générique*

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For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams*.

* See web site address on title page.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

THERMISTORS –

DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT –

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.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60738-1 has been prepared IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 1982 and constitutes a technical revision.

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

FDIS	Report on voting
40/1080/FDIS	40/1096/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.

Annex A forms an integral part of this standard.

Annexes B and C are for information only.

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

THERMISTORS –

DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT –

Part 1: Generic specification

1 General

1.1 Scope

This International Standard prescribes terms and methods of test for positive step-function temperature coefficient thermistors, insulated and non-insulated types, typically made from ferro-electric semi-conductor materials.

It establishes standard terms, inspection procedures and methods of test for use in detail specifications for Qualification Approval and for Quality Assessment Systems for electronic components.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

In the case of IEC 60068 publications, the referenced edition shall be used, regardless of any subsequent new edition(s) and amendment(s).

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60050: *International Electrotechnical Vocabulary*

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

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-3:1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc and guidance: 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*

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

IEC 60068-2-21:1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*

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)*

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

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*

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: *Graphical symbols for diagrams*

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

IEC QC 001003: *Guidance documents*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

2 Technical data

2.1 Units and symbols

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

IEC 60027

IEC 60050

IEC 60617

ISO 1000

2.2 Definitions

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

2.2.1
type
a group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection

They are generally covered by a single detail specification.

NOTE – Components described in several detail specifications may, in some cases, be considered as belonging to the same type but they are generally covered by a single detail specification.

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

2.2.3
thermistor
a thermally sensitive semiconducting resistor which exhibits a significant change in electrical resistance with a change in body temperature

2.2.4
positive temperature coefficient thermistor
a thermistor, the resistance of which increases with its increasing temperature throughout the useful part of its characteristic

2.2.5
positive step-function temperature coefficient thermistor (PTC)
a thermistor which shows a step-like increase in its resistance when the increasing temperature reaches a specific value

A PTC thermistor will show secondary effects which have to be taken into account.

2.2.6
zero-power resistance (R_T)
the value of the resistance of a PTC thermistor, at a given temperature, under conditions such that the change in resistance due to the internal generation of heat is negligible with respect to the total error of measurement

NOTE – Any resistance value of a PTC thermistor is dependent on the value and the mode of the applied voltage (a.c. or d.c.) and, when an a.c. source is used, on the frequency (see 2.2.8 and 2.2.9).

2.2.7
nominal zero-power resistance (R_n)
the d.c. resistance value of a thermistor measured at a specified temperature, preferable at 25 °C, with a power dissipation low enough that any further decrease in power will result only in a negligible change in resistance. Zero-power resistance may also be measured using a.c. if required by the detail specification.

2.2.8
voltage dependency
a secondary effect, exhibiting a decreasing resistance with increasing voltage across the thermistor when measured at a constant body temperature

2.2.9
frequency dependency
a secondary effect exhibiting a substantial decrease of the positive temperature coefficient of the thermistor with increasing frequency

2.2.10
resistance/temperature characteristics
the relationship between the zero-power resistance of a thermistor and the temperature of the thermosensitive element when measured under specified reference conditions (see figure 1)

NOTE – PTC thermistors may have more than one resistance/temperature characteristic specified.

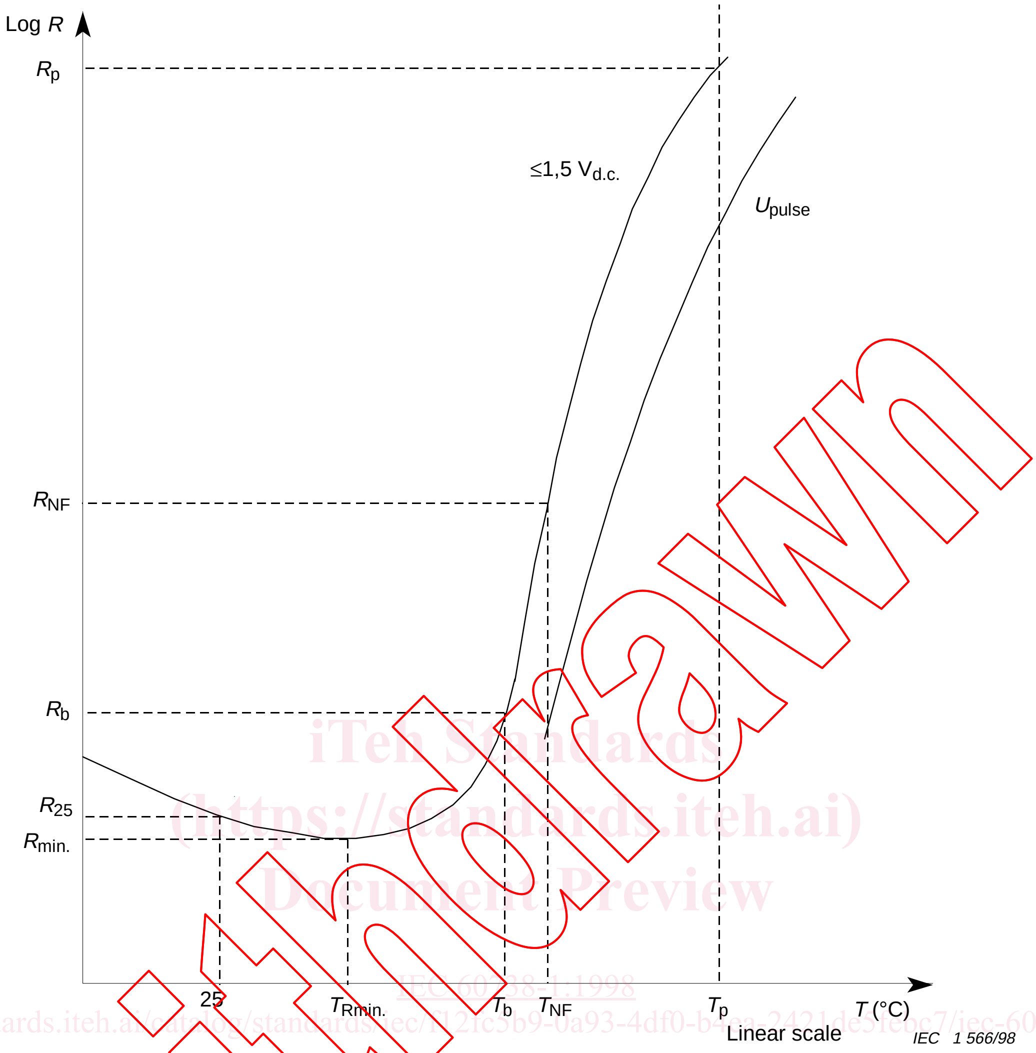
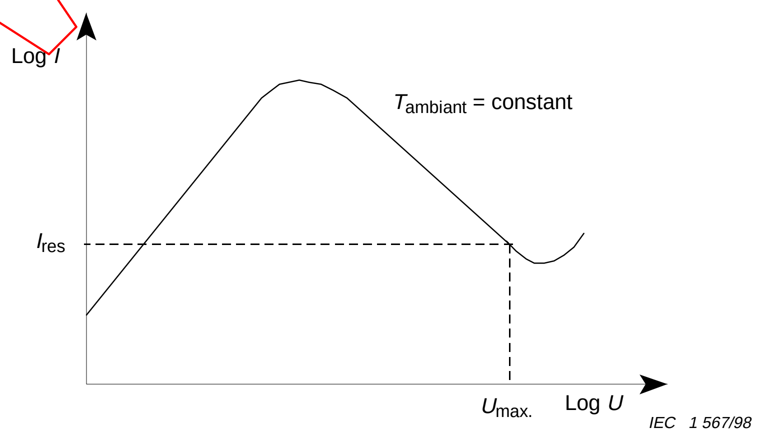


Figure 1 – Typical resistance-temperature characteristic and definitions for PTC thermistors (at zero-power)

2.2.11
current/voltage characteristic
the relationship in still air at 25 °C (unless otherwise stated) between the applied voltage (d.c. and/or a.c.), at the thermistor terminations and the current under steady state conditions (see figure 2)



NOTE 1 – $U_{max.}$ will be specified by the manufacturer.

NOTE 2 – The breakdown voltage is the value beyond which the thermistor's voltage handling capability no longer exhibits its characteristic property.

Figure 2 – Typical current/voltage characteristic for PTC thermistors

2.2.12
nominal functioning temperature (T_{NF})
the nominal temperature at the steep part of the resistance temperature characteristic at which the system controlled by the thermistor, is designed to operate

2.2.13
switching temperature (T_b)
the temperature at which the step-like function commences

2.2.14

minimum resistance ($R_{min.}$)
the minimum value of the zero-power resistance/temperature characteristic (see figure 1)

2.2.15
resistance at switching temperature (R_b)
the value of the zero-power resistance corresponding to the switching temperature

It is defined as $R_b = 2 \times R_{min}$. As an alternative definition $R_b = 2 \times R_{25}$ can be used. If this definition is used, this shall be explicitly stated in the detail specification.

2.2.16

temperature for minimum resistance ($T_{Rmin.}$)

that temperature at which $R_{min.}$ occurs

2.2.17
temperature T_p
that temperature, higher than T_b, in the PTC part of the resistance/temperature characteristic for which a minimum value R_p of the zero-power resistance is specified

2.2.18
resistance R_p
the zero-power resistance at temperature T_p measured at maximum voltage or a voltage specified in the detail specification and given as a minimum value

NOTE – The measurement should be made under such conditions that any change in resistance due to internal generation of heat is negligible with respect to the total error of measurement. The applied voltage and the characteristics of any pulse used should be given in the detail specification; when applying the maximum voltage, the maximum overload current may not be exceeded.

2.2.19
average temperature coefficient of resistance at a stated voltage (α_R)
the rate of change of resistance with temperature expressed as %/K

It is calculated from the formula:

$$\alpha_R = \frac{100}{(T_p - T_b)} \times \ln \frac{R_p}{R_b}$$

where T_p exceeds T_b by a minimum of 10 K.

The temperatures T_p and T_b are to be given, if applicable, and the measurement conditions for R_b and R_p should be the same, unless otherwise specified in the detail specification.

NOTE – The detail specification may specify the measurement of the temperature coefficient of resistance in a narrow temperature range where its value is a maximum, together with a suitable test method.

2.2.20
upper category temperature (UCT)
the maximum ambient temperature for which a thermistor has been designed to operate continuously at zero power

2.2.21
lower category temperature (LCT)
the minimum ambient temperature for which a thermistor has been designed to operate continuously at zero power

2.2.22
maximum voltage ($U_{max.}$)
the maximum a.c. or d.c. voltage which may be continuously applied to the thermistor without exceeding the maximum overload current

2.2.23
operating temperature range at maximum voltage
the range of ambient temperatures at which the thermistor can operate continuously at the maximum voltage without exceeding the maximum overload current

2.2.24
isolation voltage (applicable only to insulated thermistors)
the maximum peak voltage which may be applied under continuous operating conditions between any of the thermistor terminations and any conducting surface

2.2.25
maximum overload current (I_{mo})
the value of current for the operating temperature range, which shall not be exceeded

NOTE – It may be necessary to limit the current through the thermistor by the use of a series resistor R_S.

2.2.26
residual current (I_{res})
the value of current in the thermistor at a specified ambient temperature (preferably 25 °C) under steady-state conditions. The applied voltage is the maximum voltage unless otherwise specified (see figure 2)

2.2.27
tripping current (I_t)
the lowest current which will cause the thermistor to trip to a high resistance condition at a specified temperature (preferably 25 °C) and within a time to be specified in the detail specification

2.2.28
maximum non-tripping current ($I_{max.\ nt}$)
the maximum current at a specified ambient temperature (preferably 25 °C), which the thermistor will conduct indefinitely in its low resistance condition

2.2.29
inrush current (I_{in})
the current occurring during the transient period from the moment of switching to the steady-state condition

2.2.30
peak inrush current ($I_{in\ p}$)
the peak inrush current is the maximum value of current during the transient period (see figure 3)

2.2.31
minimum peak inrush current ($I_{in\ p\ min.}$)
the lowest specified value of the peak of the inrush current

2.2.32
maximum peak inrush current ($I_{in\ p\ max.}$)
the maximum specified value of the peak inrush current

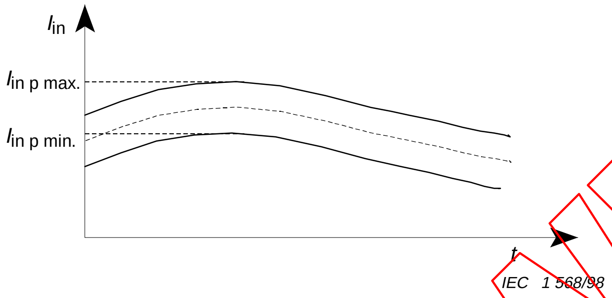


Figure 3 – I_{in} against t at U_{dc}

2.2.33
peak-to-peak inrush current ($I_{in\ pp}$) (for a.c. conditions only)
the value of the inrush current measured between adjacent positive and negative peaks (see figure 4)

2.2.34
minimum peak-to-peak inrush current ($I_{in\ pp\ min.}$)
the lowest specified value of the peak-to-peak inrush current

2.2.35
maximum peak to peak inrush current ($I_{in\ pp\ max.}$)
the maximum specified value of the peak-to-peak inrush current

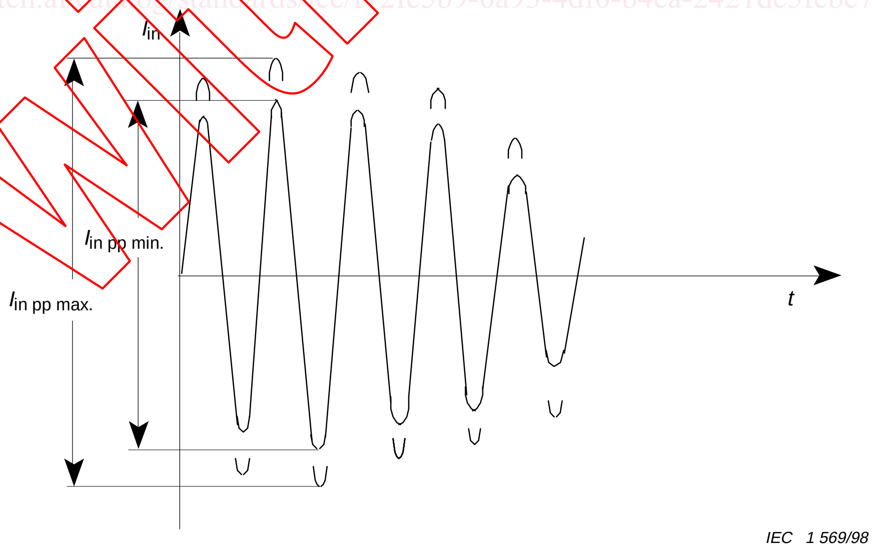


Figure 4 – I_{in} against t at U_{rms}

2.2.36
peak inrush power ($P_{in\ p}$)
the peak power ($U \times I_{in\ p}$) measured at the maximum peak value of the current occurring during the transient period from the moment of switching to the steady-state operating condition measured under specified conditions of ambient temperature, voltage and circuit

2.2.37
maximum peak inrush power ($P_{in\ p\ max.}$)
the maximum peak power which can occur during the transient period before the thermistor reaches its steady-state operating condition

2.2.38
maximum power ($P_{max.}$)
the maximum power is the power ($U_{max.} \times I_{res}$) which can be dissipated continuously by the thermistor when the maximum voltage is applied under specified conditions of ambient temperature, circuit and thermal dissipation when thermal equilibrium is obtained

NOTE – If the power is supplied by an a.c. source then the voltage and current should be measured with true r.m.s. meters.

2.2.39
dissipation factor (δ)
the quotient (in W/K) of the change in power dissipation in the thermistor and the resultant change of the body temperature under specified ambient conditions (temperature, medium)

2.2.40
thermal resistance (R_{th})
the quotient (in K/W) of the temperature difference between the thermistor and its ambient and the power dissipated by the thermistor under specified ambient conditions (temperature, medium)

NOTE – "Dissipation factor" and "thermal resistance" are mutually reciprocal.

2.2.41
heat capacity (C_{th})
the energy (in J) the thermistor needs to increase its body temperature by 1 K

2.2.42
response time

a) Response time by ambient temperature change (t_a)

   The time (in seconds) required by a thermistor to change its temperature between two defined conditions when subjected to a change in ambient temperature.

b) Response time by power change (t_p)

   The time (in seconds) required by a thermistor to change its temperature between two defined conditions of power input.

2.2.43
thermal time constant
the thermal time constant (ideal) for a thermistor is the product of its heat capacity and its thermal resistance

a) Thermal time constant by ambient temperature change (τ_a)

   The time required for a thermistor to respond to 63,2 % of an external step change in ambient temperature.

b) Thermal time constant by cooling (τ_c)

   The time required for a thermistor to cool by 63,2 % of its temperature excess, due to electrical heating, in still air.