

NTC Thermistors

Summary

Issue date: April 2011

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NTC Thermistors

Summary

NTC(Negative Temperature Coefficient) Thermistors are manufactured from sintered metal oxides. Each thermistor consists of a combination of two to four of the following materials: Manganese, Nickel, Cobalt and Copper.

These semiconductor resistors exhibit decreasing resistance characteristics with increasing temperature, and have a low thermal time constant resulting in an extremely high rate of resistance change to accurately track the temperature.

FEATURES

TDK NTC thermistors are high-quality thermistors that have been manufactured from carefully selected high-quality materials. TDK uses unique fine ceramics manufacturing and precision machining to manufacture its high quality thermistors.

- Small, compact, and highly responsive to temperature changes.
- Tightly controlled B constant for predictable and accurate temperature measurement.
- Highly reliable.
- The chip type, the glass diode type, and the resin coated type are prepared according to the applications. Moreover, it is possible to correspond widely as an assembly product which makes the best use of these features.

APPLICATIONS

TDK NTC thermistors are widely used as the followings.

Field	Applications
Automobile	Intake-air temperature sensors, exhaust-air temperature sensors, cooling-water temperature sensors, lubricating-oil temperature sensors
Air conditioning	Oil fan heaters, solar heating systems, air conditioners
Office automation equipment	Copier-facsimiles, computer equipment
Medical instruments	Clinical thermometers, intravenous injection temperature regulators, neonatal incubators
Cooking appliances	Microwave ovens, steam ovens, electric crock pots, electric ranges, electric ovens
Home medical electronics	Electronic clinical thermometers, warm washing toilets, electric curling irons
Household appliances	Refrigerators, irons, electric water-heaters, electric tea-pots, electric coffee-makers, washing machines, TVs, video cassette recorders, stereo sets, radios
Information and Telecommunications	Cellular phones, chargeable battery pack, personal computers

PHYSICAL PROPERTIES OF NTC THERMISTORS

INITIAL RESISTANCE

Thermistor resistance is a function of absolute temperature as indicated by the following relationship:

$$R=R_0 \cdot \exp B \left(\frac{1}{T} - \frac{1}{T_0} \right) \dots\dots\dots (1)$$

Here R_0 , $R(k\Omega)$ are the respective resistance values when the surrounding temperature is T_0 , $T(K)$. B is the thermistor constant(B constant below).

B CONSTANT

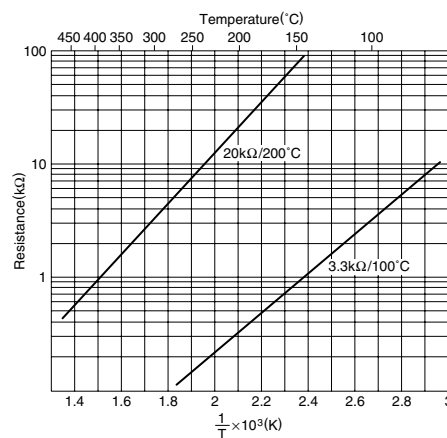
The B constant is found from the following equation:

$$B = \frac{2.3026(\log R - \log R_0)}{\frac{1}{T} - \frac{1}{T_0}} \dots\dots\dots (2)$$

This B characteristic is indicated by the slope of the linear plot of $\log R-1/T$ inverse absolute temperature.

The B constant value is generally in the vicinity of 2500K to 5000K. B constant values of 3000K to 4000K are frequently used for measurements.

Resistance-temperature characteristics (Fig.1)



TEMPERATURE COEFFICIENT

The relationship between temperature coefficient α and B becomes:

$$\alpha = \frac{1}{R} \cdot \frac{dR}{dT} = - \frac{B}{T^2} \times 100 (\%/^{\circ}C) \dots\dots\dots (3)$$

The negative sign of the temperature coefficient indicates that the temperature coefficient decreases as both thermistor resistance and temperature rise. If B is taken as 3400K, the temperature coefficient found at 20°C (293.15K) becomes $-4\%/^{\circ}C$.

HEAT DISSIPATION COEFFICIENT

Temperature rises due to thermal energy formed as electrical current flows through the thermistor. The thermistor temperature T_0 is then related to the surrounding temperature T_a and the electrical input W :

$$W = k(T_0 - T_a) = V \cdot I (mW) \dots\dots\dots (4)$$

$$k = \frac{W}{T_0 - T_a} (mW/^{\circ}C) \dots\dots\dots (5)$$

This k value is the heat dissipation coefficient, which represents the additional electrical power (mW/°C) needed to raise the thermistor temperature by 1°C. This heat dissipation coefficient varies with changes in the measurement and environmental conditions. When a thermistor is used for temperature measurement, it is naturally important to lower the applied electrical current as much as possible in order to reduce measurement error resulting from self heating.

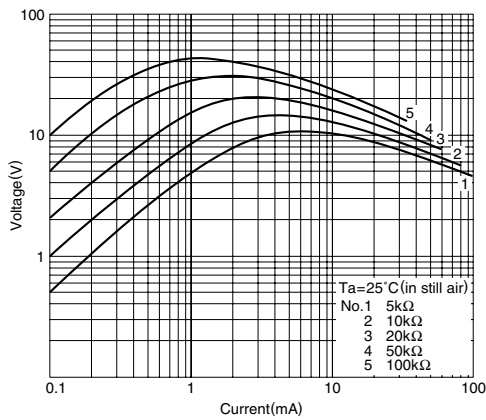
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VOLTAGE - CURRENT CHARACTERISTIC

The voltage - current characteristic indicates the drop in voltage as electrical current through the thermistor is gradually increased.

Voltage-current characteristics (Fig.2)



HEATING TIME CONSTANT

The time period required to heat up a thermistor from a certain temperature T_0 over a target temperature rise is called the heating time constant. Various types of heating time constants are indicated by the symbols shown in Table 1 as determined by the percent change from T_0 toward the target temperature. The standard change is typically taken to be 63.2%.

Thermal time constants (Fig.3)

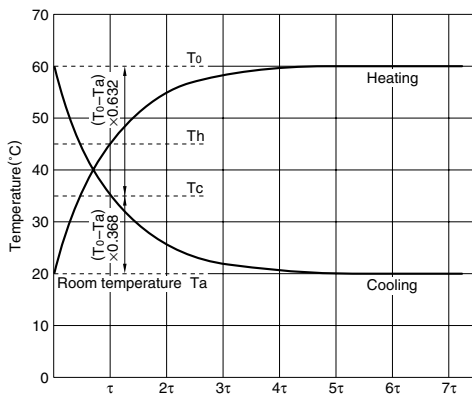


Table 1 Heating time constant and temperature change ratio

Code	Rate of change (%) for $T_0 - T_a$
τ	63.2
2τ	86.5
3τ	95.0
4τ	98.2
5τ	99.4
6τ	99.8
7τ	99.9

PRODUCT IDENTIFICATION

NTC D S 3H G 202 J C 3 ○ ○ ○○○
 (1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12)

- Chip type: Please refer to the NTCG Series catalog (eb221_ntcg).
- Assembled products: Please refer to the NTCGP/NTCDP Series catalog (eb225_ntcdp).

(1) This code denotes NTC thermistors.

(2) Structural classification code

D	Glass sealed diode shape
G	Multilayer element

(3) Assembly classification code

S	Without processing
C	Short cut lead wire
E	Kinked lead wire
D	Kinked lead wire with insulation tube
A	Folded radial lead wire
B	Folded radial lead wire with insulation tube
Z	Others

(4) B constant(Resistance temperature characteristics)

This code indicates the value of B constant using a combination of one numeric and one alphabetic character.

Numeric code	B constant(K)	Alphabetic code	B constant(K)
1	1000	A	0 to 50
2	2000	B	51 to 100
3	3000	C	101 to 150
4	4000	D	151 to 200
5	5000	E	201 to 250
		F	251 to 300
		G	301 to 350
		H	351 to 400
		J	401 to 450
		K	451 to 500
		L	501 to 550
		M	551 to 600
		N	601 to 650
		P	651 to 700
		Q	701 to 750
		R	751 to 800
		S	801 to 850
		T	851 to 900
		U	901 to 950
		V	951 to 999

Note: Although B constants are expressed as 1A, 1B, 2A, 2B, etc. using these two tables, the alphabetic characters do not denote tolerances; they have the meaning shown in the example below.

(Example)

1A=1000(K)

1A=1050(K)

That is, the alphabetic character(in this example, A) indicates the range of values that can be specified by the thermistor user.

(5) B constant tolerance

This code indicates tolerances using the following code.

Code	Tolerance(%)
F	±1
G	±2
H	±3
J	±5
K	±10

(6) Nominal resistance

This code indicates the resistance value existing at the specified ambient temperature by two significant digits followed by the digit 0(zero).

(Example)

470Ω	471
5kΩ	502
10kΩ	103
150kΩ	154

(7) Nominal resistance tolerance

Tolerance is identified by the following codes.

Code	Tolerance(%)
F	±1
G	±2
H	±3
J	±5

(8) Ambient temperature for nominal resistance

Ambient temperatures for specified nominal-resistance values are indicated using the following codes.

Code	Ambient temperature(°C)
A	-20
B	0
C	25
D	100
E	200
F	300
G	20
X	Others

(9) Dimensional code

3	3018(3.0×ø1.8mm)
4	4020(4.0×ø2.0mm)
5	Resin dip shape

(10) Plating specification code of lead wire

N	Ni
S	Sn

(11) Packaging style

B	Bulk
T	Taping(Tape width: 52mm)
K	Taping(Tape width: 26mm)

(12) TDK internal code

PERFORMANCE AND TEST METHODS

ELECTRICAL CHARACTERISTICS

Item	Test method	Specifications
Resistance value	Measure the value at a power level such that the influences of spontaneous heat generation can be negligible at the specified ambient temperature.	The measured values must stay within the specified limits.
B constant	Using the following expression, calculate the value from the resistances at the two specified ambient temperatures. $B=2.3026 \frac{(\log R_1 - \log R_2)}{\frac{1}{T_1} - \frac{1}{T_2}}$	The measured values must stay within the specified limits.
Heat dissipation constant	This constant denotes the power level(mW/°C) that is needed to increase the thermistor temperature by 1°C. It is calculated by the energy consumption at any two temperatures and previously measured resistance-temperature characteristic values using the following expression. $k = \frac{W}{T_0 - T_a} \text{ (mW/°C)}$	The measured values must stay within the specified limits.
Thermal time constant	Abruptly change the ambient temperature of the thermistor and measure the time until it reaches 63.2%(1τ) of the temperature difference.	The measured values must stay within the specified limits.
Withstand voltage	Apply the specified voltage to the electrically insulated section of the thermistor under the specified conditions.	No abnormalities must occur.
Rated power	Measure the maximum power level at which any increment in thermistor temperature stays within 0.2°C due to spontaneous heat generation.	The measured values must stay within the specified limits.

MECHANICAL CHARACTERISTICS

Item	Test method	Specifications
Tensile strength of terminal	Secure the thermistor body, and then apply a tensile force to it under the specified conditions and maintain this state for the specified time.	Damage must not occur.
Bending strength of terminal	Secure the thermistor body and then apply loads to it under the specified conditions. Repeat this procedure the specified number of times.	Damage must not occur.
Vibration resistance	Apply vibration under the specified conditions. Repeat this procedure the specified times.	Measured values must stay within the specified limits.
Shock resistance	Apply shock under the specified conditions. Repeat this operation the specified number of times.	Measured values must stay within the specified limits.
Solderability	Solder the thermistor terminals under the specified conditions and check their solderability.	Measured values must exceed the specified limits.
Resistance to soldering heat	Apply a thermal soldering shock to the thermistor under the specified conditions, then leave the thermistor in a standard state for the specified time(one hour or more), before measurement.	Measured values must stay within the specified limits.

ENVIRONMENTAL TESTS

Item	Test method	Specifications
Low temperature storage	Allow the thermistor to stand in air at the minimum permissible operating temperature for the specified time. Place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.
High temperature storage	Allow the thermistor to stand in air at the maximum permissible operating temperature for the specified time. Place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.
Heat cycle	Cycle the thermistor at the minimum permissible operating temperature, the maximum permissible operating temperature, and room temperature for the specified time. Repeat this cycle for the specified number of times. Subsequently, place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.
Heat shock	Cycle the thermistor at the minimum permissible operating temperature and the maximum operating temperature for the specified time respectively. Repeat this cycle for the specified number of times. Subsequently, place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.
Moisture resistance	Allow the thermistor to stand in air at the specified temperature and relative humidity for the specified times. Subsequently, place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.
High temperature loading	Apply the specified electrical load to the thermistor at the maximum permissible operating temperature for the specified time. After that, place and maintain the thermistor in a normal condition for one hour or more before measurements.	Measured values must stay within the specified limits.

- The test conditions and the specified values are decided individually.