TDK

# NTC Thermistors
# Summary

**Conformity to RoHS Directive**

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:

$$R=R_0 \bullet \exp B\left(\frac{1}{T}-\frac{1}{T_0}\right) \quad \cdots\cdots (1)$$

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

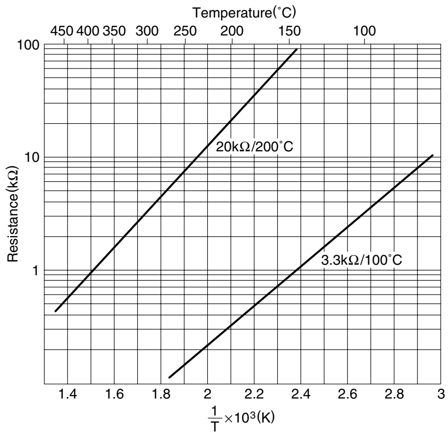
### B CONSTANT

The B constant is found from the following equation:

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

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:

$$\alpha=\frac{1}{R}\bullet\frac{dR}{dT}=-\frac{B}{T^2}\times 100(\%/°C) \quad \cdots\cdots (3)$$

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%/°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 Ta and the electrical input W:

$$W=k(T_0-Ta)=V\bullet I(mW) \quad \cdots\cdots (4)$$

$$k=\frac{W}{T_0-Ta}\ (mW/°C) \quad \cdots\cdots (5)$$

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.

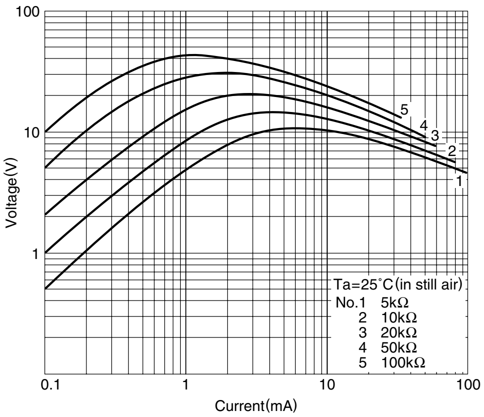
- Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.

- All specifications are subject to change without notice.

## 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)

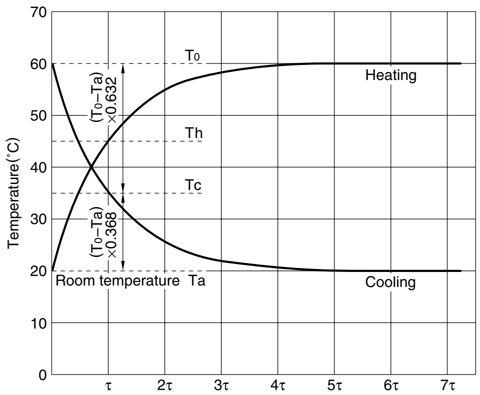



Table 1 Heating time constant and temperature change ratio

| Code | Rate of change (%) for $T_0$ -Ta |
|---|---|
| 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) |
|---|---|
| 1 | 1000 |
| 2 | 2000 |
| 3 | 3000 |
| 4 | 4000 |
| 5 | 5000 |

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.

| Alphabetic code | B constant(K) |
|---|---|
| A | 0 to 50 |
| B | 51 to 100 |
| C | 101 to 150 |
| D | 151 to 200 |
| 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 |

(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. $B=2.3026\frac{(\log R-\log R_2)}{\frac{1}{T}-\frac{1}{T_0}}$ | 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. $k=\frac{W}{T_0-T_a}$ (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. |

### MECHANICL 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.