NTC热敏电阻的基本特性

NTC热敏电阻是指具有负温度系数的热敏电阻。是使用单一高纯度材料、具有接近理论密度结构的高性能陶瓷。因此，在实现小型化的同时，还具有电阻值、温度特性波动小、对各种温度变化响应快的特点，可进行高灵敏度、高精度的检测。本公司提供各种形状、特性的小型、高可靠性产品，可满足广大客户的应用需求。

NTC Thermistor basic properties

Negative temperature coeffcient(NTC)thermistors are manufactured from high purity and uniform materials to achieve a construction of near-perfect theoretical density. This ensures small size, tight resistance and B-value tolerances, and fast response to temperature variations, making a highly sensitive and precision component. Thermistor is available in a wide range of types to meet your demands for small size and high reliability.

■电阻－温度特性

热敏电阻的电阻－温度特性可近似地用式1表示。

■Resistance - temperature characteristic

The resistance and temperature characteristics of a thermistor can be approximated by equation 1.

式1(eq1) $R=R_0 \exp\{B(I/T-I/T_0)\}$

R ：温度T(K)时的电阻值
R_0：温度T_0(K)时的电阻值
B ：B值
※T(K)= t(˚C)+273.15

R : resistance at absolute temperature T(K)
R_0 : resistance at absolute temperature T_0(K)
B : B value
※T(K)= t(˚C)+273.15

但实际上，热敏电阻的B值并非是恒定的，其变化大小因材料构成而异，最大甚至可达5K/˚C。
因此在较大的温度范围内应用式1时，将与实测值之间存在一定误差。

The B value for the thermistor characteristics is not fixed, but can vary by as much as 5K/˚C according to the material composition. Therefore equation 1 may yield different results from actual values if applied over a wide temperature range.

此处，若将式1中的B值用式2所示的作为温度的函数计算时，则可降低与实测值之间的误差，可认为近似相等。

By taking the B value in equation 1 as a function of temperature, as shown in equation 2, the difference with the actual value can be minimized.

式2(eq2) $B_T=CT^2+DT+E$

上式中，C、D、E为常数。
另外，因生产条件不同造成的B值的波动会引起常数E发生变化，但常数C、D不变。因此，在探讨B值的波动量时，只需考虑常数E即可。

C, D, and E are constants.
The B value distribution caused by manufacturing conditions will change the constant E, but will have no effect on constants C or D. This means, when taking into account the distribution of B value, it is enough to do it with the constant E only.

●常数C、D、E的计算
常数C、D、E可由4点的(温度、电阻值)数据(T_0，R_0)(T_1，R_1)(T_2，R_2)(T_3，R_3)，通过式3～6计算。
首先由式样3根据T_0和T_1,T_2,T_3的电阻值求出B_1,B_2,B_3,然后代入以下各式样。

●Calculation for constants C, D and E
Using equations 3~6, constants C, D and E can be determined through four temperature and resistance value data points (T_0, R_0). (T_1, R_1). (T_2, R_2) and (T_3, R_3).
With equation 3, B_1, B_2 and B_3, can be determined from the resistance values for To and T_1, T_2, T_3 and then substituted into the equations below.

式3(eq3) $$B_n=\frac{I_n(R_n/R_0)}{\frac{I}{T_n}-\frac{I}{T_0}}$$

式4(eq4) $$C=\frac{(B_1-B_2)(T_2-T_3)-(B_2-B_3)(T_1-T_2)}{(T_1-T_2)(T_2-T_3)(T_1-T_3)}$$

式5(eq5) $$D=\frac{B_1-B_2-C(T_1+T_2)(T_1-T_2)}{(T_1-T_2)}$$

式6(eq6) $$E=B_1-DT_1-CT_1\cdot T_1$$

●电阻值计算例
试根据电阻－温度特性表，求25˚C时的电阻值为5(kΩ)，B值偏差为50(K)的热敏电阻在10˚C～30˚C的电阻值。

●Example
Using a resistance-temperature characteristic chart, the resistance value over the range of 10˚C~30˚C is sought for a thermistor with a resistance of 5kΩ and a B value deflection of 50K at 25˚C.

●步骤
①根据电阻－温度特性表，求常数C、D、E。

●Process
①Determine the constants C, D and E from the resistance-temperature chart.

T_0＝25＋273.15 T_1＝10＋273.15 T_2＝20＋273.15 T_3＝30＋273.15

②代入$B_T=CT^2+DT+E+50$，求B_T。

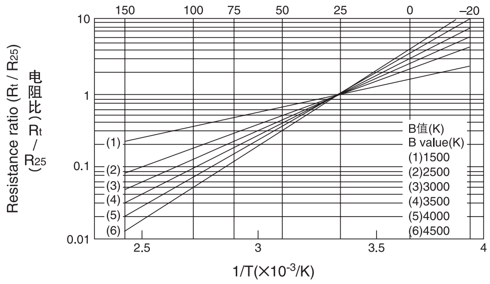
③将数值代入$R=5\exp\{(B_T I/T-I/298.15)\}$，求R。
※T : 10+273.15～30+273.15

②$B_T= CT^2+TD+E+50$; substitute the value into equation and solve for B_T

③$R= 5\exp\{B_T (I/T-I/298.15)\}$; substitute the values into equation and solve for R
※T : 10+273.15~30+273.15

●电阻－温度特性图如图1所示

●Results of plotting the resistance-temperature characteristics are shown figure 1



电阻－温度特性(图—1)
RESISTANCE-TEMPERATURE CHARACTERISTIC(Fig. 1)

■电阻温度系数

所谓电阻温度系数(α)，是指在任意温度下温度变化1˚C(K)时的零负载电阻变化率。

电阻温度系数(α)与B值的关系，可将式1微分得到。

■Resistance temperature coefficient

The resistance-temperature coefficient (α) is defined as the rate of change of the zero-power resistance associated with a temperature variation of 1˚C at any given temperature.
The relationship between the resistance-temperature coefficient (α) and the B value can be obtained by differentiating equation 1 above.

$$\alpha = \frac{I}{R} \cdot \frac{dR}{dT} \times 100 = -\frac{B}{T^2} \times 100(\%/^\circ C) \cdot\cdot\cdot\cdot (2.1)$$

这里α前的负号(－)，表示当温度上升时零负载电阻降低。

A negative value signifies that the rated zero-power resistance decreases

■散热系数(JIS-C2570)

散热系数(δ)是指在热平衡状态下，热敏电阻元件通过自身发热使其温度上升1˚C时所需的功率。

在热平衡状态下，热敏电阻的温度T_1、环境温度T_2及消耗功率P之间关系如下式所示。

■Heat dissipation constant (JIS-C2570)

The dissipation constant (δ) indicates the power necessary for increasing the temperature of the thermistor element by 1˚C through self-heating in a heat equilibrium.
Applying a voltage to a thermistor will cause an electric current to flow, leading to a temperature rise in the thermistor. This " intrinsic heating " process is subject to the following relationship among the thermistor temperature T_1, ambient temperature T_2, and consumed power P.

$$\delta = \frac{P}{T_1 - T_2} (mW/^\circ C) \cdot\cdot\cdot\cdot (2.2)$$

※$(P = I^2 \cdot R = I \cdot V)$

产品目录记载值为下列测定条件下的典型值。

①25˚C静止空气中。
②轴向引脚、径向引脚型在出厂状态下测定。

Measuring conditions for all parts in this catalog are as follows:

①Room temp is 25˚C
②Axial and radial leaded parts were measured in their shipping condition.

■额定功率(JIS-C2570)

在额定环境温度下，可连续负载运行的功率最大值。

产品目录记载值是以25˚C为额定环境温度、由下式计算出的值。

(式)额定功率=散热系数×(最高使用温度－25)

■Power rating (JIS-C2570)

The power rating is the maximum power for a continuous load at the rated temperature.

For parts in this catalog, the value is calculated from the following formula using 25˚C as the ambient temperature.
(formula) Rated power=heat dissipation constant × (maximum operating temperature-25˚C)

■最大运行功率

这是使用热敏电阻进行温度检测或温度补偿时，自身发热产生的温度上升容许值所对应功率。(JIS中未定义。)容许温度上升t˚C时，最大运行功率可由下式计算。
最大运行功率=t×散热系数…(3.3)

■Maximum operating power

Definition : The power to reach the maximum operating temperature through self heating when using a thermistor for temperature compensation or as a temperature sensor. (No JIS definition exists.) The maximum operating power, when t ˚C is the permissible temperature rise, can be calculated using the following formula.
Maximum operating power= t×heat dissipation constant··· (3.3)

■对应环境温度变化的热响应时间常数(JIS-C2570)

指在零负载状态下，当热敏电阻的环境温度发生急剧变化时，热敏电阻元件产生最初温度与最终温度两者温度差的63.2%的温度变化所需的时间。

热敏电阻的环境温度从T_1变为T_2时，经过时间t与热敏电阻的温度T之间存在以下关系。

■Thermal time constant for changes in surrounding temperature (JIS-C2570)

A constant expressed as the time for the temperature at the electrodes of a thermistor, with no load applied, to change to 63.2% of the difference between their initial and final temperatures, during a sudden change in the surrounding temperature.

When the surrounding temperature of the thermistor changes from T_1 to T_2, the relation between the elapsed time t and the thermistors temperature T can then be expressed by the following equation.

$$T=(T_1-T_2)\exp(-t/\tau)+T_2\cdots\cdots(3.1)$$
$$=(T_2-T_1)\{1-\exp(-t/\tau)\}+T_1\cdots\cdots(3.2)$$

常数τ称热响应时间常数。
上式中，若令t=τ时，则$(T-T_1)/(T_2-T_1)=0.632$。

换言之，如上面的定义所述，热敏电阻产生初始温度差63.2%的温度变化所需的时间即为热响应时间常数。

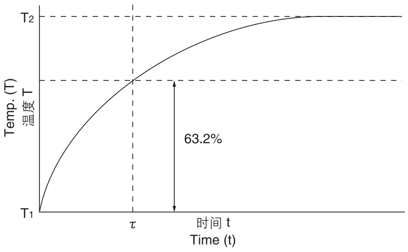
经过时间与热敏电阻温度变化率的关系如下表所示。

The constant τ is called the heat dissipation constant.
If t= τ, the equation becomes : $(T-T_1) / (T_2-T_1) = 0.632$

In other words, the above definition states that the thermal time constant is the time it takes for the temperature of the thermistor to change by 63.2% of its initial temperatrue difference.
The rate of change of the thermistor temperature versus time is shown in table 1.

t	$\frac{T-T_1}{T_2-T_1}$
τ	63.2%
2τ	86.5%
3τ	95.0%
4τ	98.2%
5τ	99.4%

表-1 热响应时间常数　Table-1 Thermal Time Constant



产品目录记录值为下列测定条件下的典型值。
①静止空气中环境温度从50˚C至25˚C变化时，热敏电阻的温度变化至34.2˚C所需时间。
②轴向引脚、径向引脚型在出厂状态下测定。

另外应注意，散热系数、热响应时间常数随环境温度、组装条件而变化。

Measuring conditions for parts in this catalog are as follows:
①Part is moved from a 50˚C envirconment to a still air 25˚C environment until the temperature of the thermistor reaches 34.2˚C.
②Axial and radial leaded parts are measured in their shipping form.

Please note, the thermal dissipation constant and thermal time constant will vary acccrding to environment and mounting conditions

■温度传感器使用注意事项

请严格遵守以下事项，否则可能会造成温度传感器损坏、使用设备损伤或引起误动作。

①传感器是按不同用途分别进行设计的。若要用于规定以外的用途时，请就使用环境条件与本公司联系洽谈。

②设计设备时，请进行传感器贴装评估试验，确认无异常后再使用。

③请勿在过高的功率下使用传感器。
④由于自身发热导致电阻值下降时，可能会引起温度检测精度降低、设备功能故障，故使用时请参考散热系数，注意传感器的外加功率及电压。

⑤请勿在使用温度范围以外使用。
⑥请勿施加超出使用温度范围上下限的急剧温度变化。

⑦将传感器作为装置的主控制元件单独使用时，为防止事故发生，请务必采取设置〝安全电路〞、〝同时使用具有同等功能的传感器〞等周全的安全措施。

⑧在有噪音的环境中使用时，请采取设置保护电路及屏蔽传感器(包括导线)的措施。

⑨在高湿环境下使用护套型传感器时，应采取仅护套头部暴露于环境(水中、湿气中)、而护套开口部不会直接接触到水及蒸气的设计。

⑩请勿施加过度的振动、冲击及压力。
⑪请勿过度拉伸及弯曲导线。
⑫请勿在绝缘部和电极间施加过大的电压。否则，可能会产生绝缘不良现象。
⑬配线时应确保导线端部(含连接器)不会渗入〝水〞、〝蒸气〞、〝电解质〞等，否则会造成接触不良。

⑭请勿在腐蚀性气体的环境(Cl2、NH3、SOX、NOX)以及会接触到电解质、盐水、酸、碱、有机溶剂的场所中使用。

⑮金属腐蚀可能会造成设备功能故障，故在选择材质时，应确保金属护套型及螺钉紧固型传感器与安装的金属件之间不会产生接触电位差。

使用时若有其他不明之处，请垂询本公司销售人员。

■Caution in Thermistor Sensor usage

Due to the possibilities of destruction of the sensor, damage or miss use of equipment, please strictly follow below matter.

①The sensor is designed for individual usage. When it is going to be used beyond the specified condition, please speak to your daily contact person for our products.
②Whenever designing the equipment, make sure to check sensor operation and if there is no lack of quality.
③Do not use the sensor exceeding rated electric power.
④Due to possibility of causing the decrease of the value of resistance with self heat and malfunction of the equipment or the precision decrease of the inspection temperature, carefully refer to the dissipation constant usage of electric power and voltage.
⑤Do not use the sensor beyond operating temperature range.
⑥Avoid from exceeding radical temperature change, which is beyond operating temperature range.
⑦In case of independently use of the sensor as a main control of the device, make sure to design and devise through safety measures for [safe circuit] and [parallel use with same function sensor] etc, to prevent from accident.
⑧Under the environment which receives the influence of electric noise, make sure to take countermeasure by installing a protection circuit and seal the sensor (including the lead wire).
⑨When the case type sensor is used under high humidity environment, make sure to design so that the protected case tip must be exposed to environment (in water, moisture) condition, and open part of the case must be prevented from not touching water and steam directly.
⑩Do not add excessive vibrating shocking pressure.
⑪Avoid from excessive pulling and bending of the lead wire.
⑫Do not impress excessive voltage in the insulated part and between the electrode. This might cause to occur the insulated malfunction.
⑬Consider wiring, due to contact failure might occur if the terminal of the lead wire (including the connector) is immersed into [water] [steam] [electrolyte] etc.
⑭Do not use in corrosiveness gas atmosphere (Cl2, NH3, SOX, NOX) and at the place where the sensor touches the electrolytic, brine, acid, alkaline and organic solvent.
⑮Due to possibility of the equipment becoming malfunction depending upon metal corrosion, consider not to cause potential difference with the contact metal for the case and screw equipped type sensor.
If there is any others unclear point, please inquire to our company sales in-charge.