Murata Leverages on NTC Thermistor to Sense Temperature

Getting the applied voltage and the features of the A/D converter or the voltage dividing resistance that provides optimal design are important in the circuit's design.

The negative temperature coefficient (NTC) thermistor is a kind of ceramic semiconductor and a temperature sensor that has negative temperature characteristics, that is, its resistant values decrease as ambient temperatures rise. The NTC thermistor's resistance changes are large in a wide temperature range. With recent innovations in production methods, small chip-type NTC thermistors with narrow deviations can now be supplied at low prices. For these reasons, NTC thermistors are applied widely as temperature detection devices in mobile devices, secondary batteries and automobiles.

Fig. 1 shows the features of a typical NTC thermistor that has a resistance value of 10kΩ at room temperature or 25°C. The resistance value decreases in an exponential rate as temperatures rises.

An engineer need to have some level of expertise when designing a temperature detection circuit using an NTC thermistor. If successful, it offers several gains and its output can be freely adjusted according to the application. Moreover, Murata Manufacturing Co., Ltd. also offers a tool to assist during the circuit design.

Temperature Detection Circuit Design

Fig. 2 shows a common temperature detection circuit that uses an NTC thermistor and the circuit's output voltage characteristics. In the circuit, an NTC thermistor and a fixed resistor are connected in series and a constant voltage is imposed. Then, the divided voltage potential is output as temperature information to an analog-to-digital (A/D) converter, which is built in a microcontroller. The NTC thermistor's change in resistance and temperature is not linear, but by adjusting resistance values of the voltage dividing resistor, a large output voltage change can be obtained in a wide temperature range. In addition, by adding a fixed resistor connected with the thermistor in parallel or in series, its output voltage range can also be adjusted to make the output more linear.

Changes in output characteristics when the 9kΩ and 1.5kΩ resistors are inserted in parallel and in series are also shown. In this case, the output voltage is controlled to be anywhere between 1V and 2V.

When designing a temperature detection circuit using an NTC thermistor, it is necessary to consider the applied voltage, the resistance values of the voltage dividing resistors and others, or the specifications of an A/D converter. For instance, if the rate of change in the output voltage against the temperature falls short of an

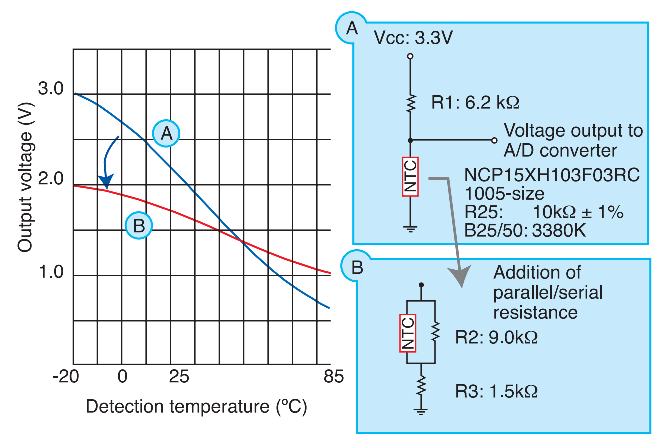

Fig. 2: Temperature detection circuit using an NTC thermistor and output voltage characteristics

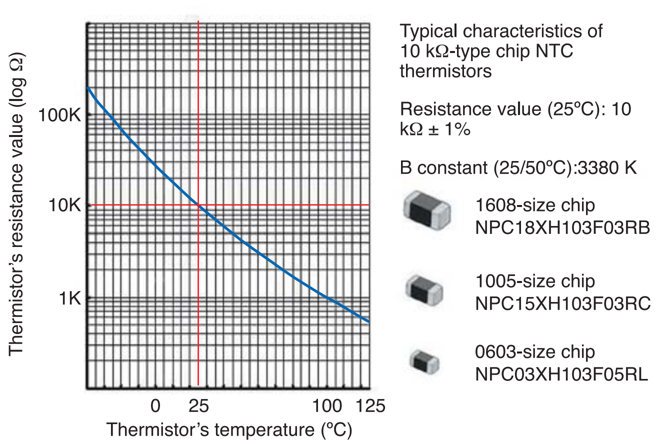

Fig. 1: NTC thermistor's resistance-temperature characteristics

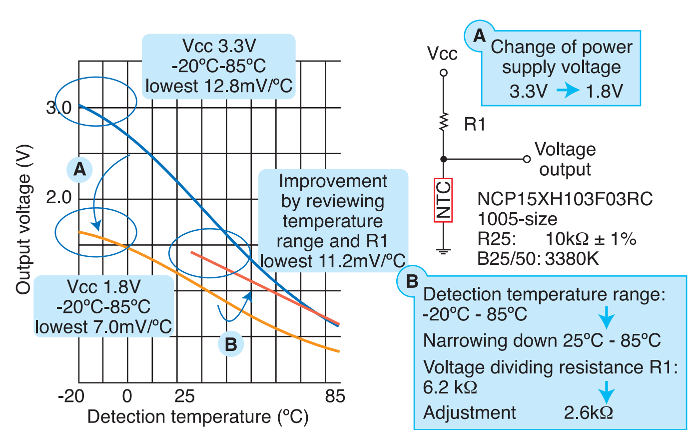

Fig. 3: Adjustment of output voltage characteristics

A/D converter's resolution capability, detection accuracy may be adversely affected. As the output voltage characteristics of a temperature detection circuit using an NTC thermistor are not completely linear, the rate of change at each temperature point is not constant. Ensuring adequate detection accuracy at a point where the rate of change becomes smallest must be considered.

Fig. 3 presents a typical application of an NTC thermistor. Within a detection temperature of -20°C and 85°C, when the voltage dividing resistance is set to make the output voltage most linear and a voltage of 3.3V is applied, the average rate of change of 22.9mV/°C and the lowest rate of 12.8mV/°C are obtained. If the applied voltage becomes 1.8V with the same circuit, the lowest rate of change falls to 7.0mV/°C. In case when a temperature detection circuit is driven at a low voltage and if the temperature range for detection with high accuracy can be narrowed down between 25°C and 85°C, the lowest rate of change can be brought down to 11.2mV/°C by adjusting the voltage dividing resistance.

A flexible circuit design is made possible by getting the voltage dividing resistance value that optimizes various conditions, such as the voltage to be applied, the necessary detection temperature range or detection accuracy, and the linearity or rate of change of the output voltage. This are among the features of an NTC thermistor.

The cost is one of the key issues to be considered in measuring temperature. Take the resistance deviation of a thermistor for instance. Common temperature detection thermistors with resistance value deviations of ±5, ±3, and ±1 percent are now available in the market. Normally, these products are priced differently, and users prefer cheaper products that feature the largest possible deviation within the allowable range. The final circuit detection errors are influenced by other factors, such as the thermistor's self-heating, deviation and temperature characteristics of voltage dividing resistance and input voltage deviation. Ultimately, it is necessary to select the needed thermistor's deviation after verification of the total allowable errors.

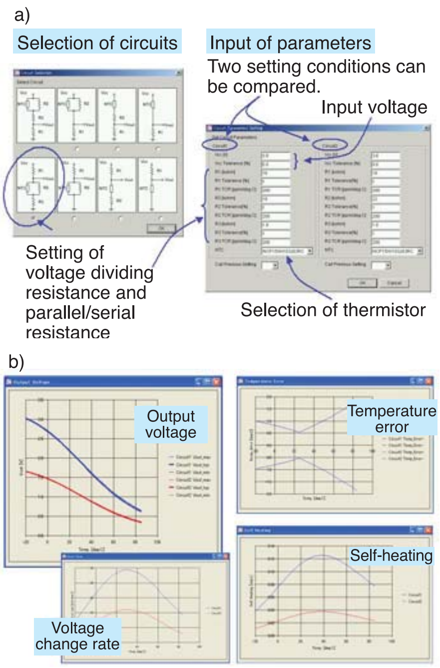

Fig. 4: Output voltage simulator

Design Support Tool

While it is possible to gain a high rate of change in a wide temperature range and flexibly adjust the output characteristics of a temperature detection circuit using an NTC thermistor, the process of verifying more than one parameter is needed to find out the optimal circuit. To address this issue, Murata Manufacturing offers the Output Voltage Simulator to support the process. This application software can be downloaded free of charge and can be installed in a personal computer to simulate a temperature detection circuit in a short period of time.

Among the company's 200 thermistors stored in the simulator, there are about 10 kinds of detection circuits and resistance temperature characteristics data that are used frequently. By selecting a circuit or a thermistor and by setting a detection temperature range, an applied voltage and other parameters, the recommended value of the voltage dividing resistance at which the output voltage becomes the most linear will be automatically calculated.

As a first step, one can start to verify the optimal circuit by using the recommended value. The output voltage characteristics can be obtained intuitively by changing the voltage dividing resistance, and by adding the parallel or serial resistance to the thermistor.

Then, items that need to be verified, such as errors in output voltage, self-heating of the thermistor, and the fluctuating rates of change at each temperature point are displayed graphically. Thus, one can easily find out the optimal circuit by changing the parameters (Figs. 4a and 4b).

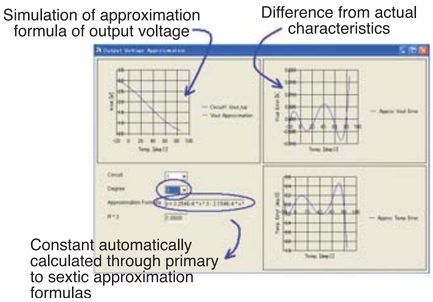

Fig. 5: Approximation formula simulation

Finally, all the results of these simulations can be saved as text data by 1°C interval, allowing the designer to take and use the necessary data into his or her design tools. If these characteristics data cannot be saved due to insufficient memory or other causes, the output voltage is converted into temperature data through an approximation formula. This simulator comes with a function that approximates output voltage through any approximation formulas that can vary from primary to sextic expressions. When an approximation formula is used, the user should pay attention to the differences from the actual characteristics, but as the temperature errors and voltage errors are shown graphically as needed, the user can find out the optimal approximation formula through comparison (Fig. 5).

Future Simulator Improvements

Murata Manufacturing offered the first version of the Output Voltage Simulator in March 2004, and the present version is available in 1.6. In an aim to make the simulator simple and speedy, the company identifies the functions with the highest priority and improves them. The company will continue to upgrade the simulator at least once a year in an effort to make it an even easier-to-use support tool that better fits the actual circuit design process.

The Output Voltage Simulator can be downloaded from the Design Tools page of Murata's homepage at http://www.murata.com/designlib/index.html.

About This Article:

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