



# Murata Protects LED Lighting Devices from Overheating

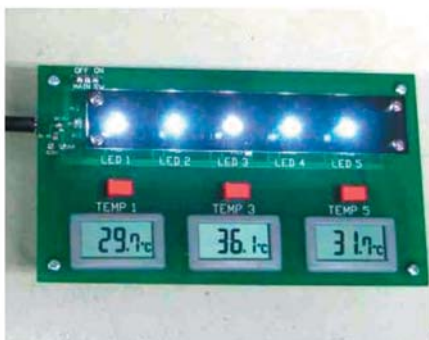
One way is installing the PTC thermistor POSISTOR to the limit resistor to prevent the LEDs to continuously build up heat despite their exposure to high temperature.

The market for light-emitting diode (LED) lighting devices is expanding rapidly primarily because of the product's improved performance and significantly lower prices. Despite such features, LED lighting devices still lack the track record compared with incandescent and fluorescent lamps because of safety issues involving their use. Specifically, amid their excellent features, such as high-efficient lighting and low power consumption, the high-brightness LED device itself can become extremely hot.

This article introduces a simple method to implement overheat protection of LED lighting devices using the POSISTOR, a positive temperature coefficient (PTC) ceramic thermistor manufactured by Murata Manufacturing Co., Ltd. This method can improve the safety of LED lighting devices at low cost.

## Using a Demonstration Board

Fig. 1 shows an LED demonstration board exhibited by Murata at CEATEC



3. This increase in resistance limits the current flow to the LED's and lowers their brightness.
4. When abnormal heat is produced, heat generated from LED's increases the temperature further and this could cause emission of fumes and fire. The use of the POSISTOR can prevent such worst-case scenarios.

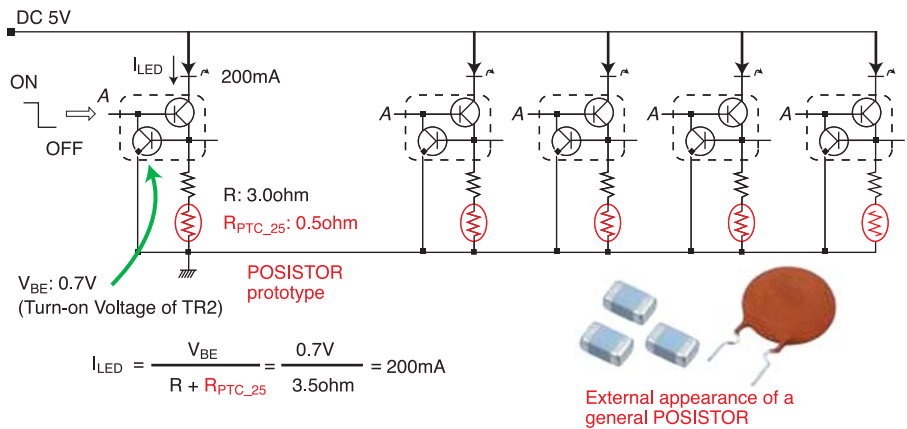


Fig. 2: Circuit diagram of the LED demonstration board

JAPAN 2009 held last October. This LED demonstration board is mounted with five surface mount type LEDs. A compact ceramic heater is installed immediately below the LEDs on the underside of this board. LCDs are used to display the board temperature near each respective LEDs. The photo on the lower right side shows forced overheating of the LEDs using the

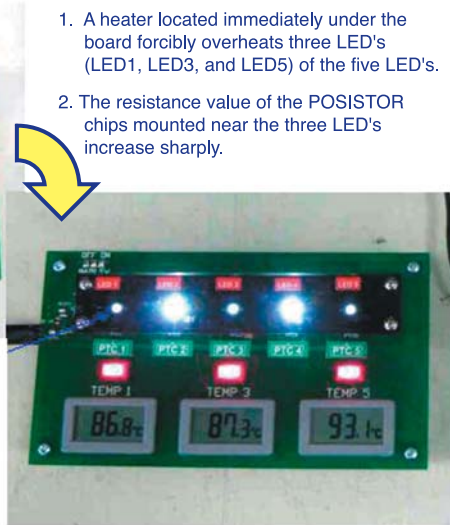


Fig.1: An LED demonstration board exhibited by Murata at CEATEC JAPAN 2009

heater installed under the board. This photo shows that the temperature of the nearby LEDs increased to more than 80°C and the brightness of the overheated LEDs lowered considerably. These results indicate that the current flowing to the LEDs is controlled by the PTC thermistor POSISTOR chips mounted near the LEDs.

Using the POSISTOR, the brightness of the LED is lowered if the LED itself produces abnormal heat or if an external factor causes an abnormal increase in the ambient temperature of the LED. As a result, the LED is prevented from continuously generating heat, thus preventing a worst-case scenario, such as emission of fumes or fire of a lighting device, to happen.

Fig. 2 shows the circuit diagram of the LED demonstration board. A constant voltage of 5V is applied to five LEDs connected in parallel. A fixed resistor (R) and the POSISTOR ( $R_{PTC}$ ) are connected to each LED in series via a pair transistor. This composite resistance ( $R+R_{PTC}$ ) sets the maximum current that flows to the LED. The pair transistor functions to switch On/Off the current that flows to the LED by controlling the potential of "A" and make the LED dimmer through

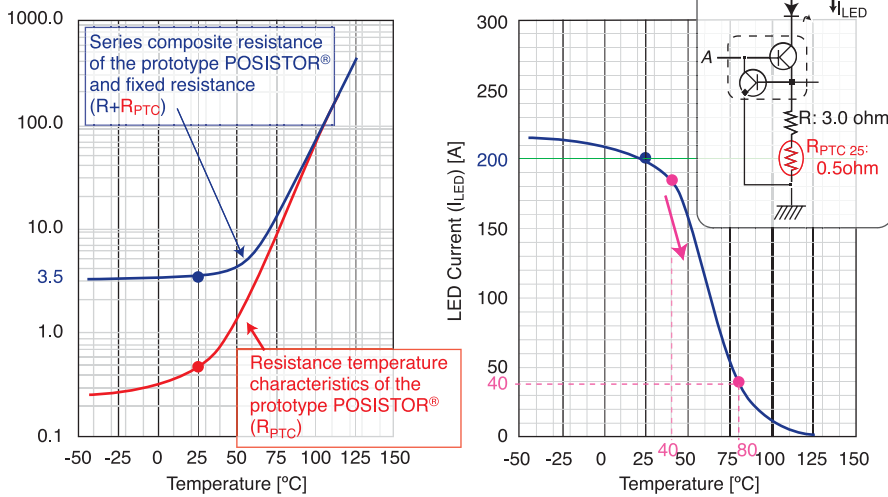


Fig. 3: Resistance temperature characteristics of the prototype POSISTOR and LED current versus temperature

pulse width modulation (PWM) control. In this case, when the potential of “A” is in the On state, the potential ( $V_{BE}$ ) between the base and emitter of “TR2” of the pair transistor is fixed at approximately 0.7V. Therefore, only the series resistance ( $R+R_{PTC}$ ) determines the current ( $I_{LED}$ ) that will flow to the LED. For example,  $R+R_{PTC}$  is 3.5ohm at the temperature of 25°C, thus a current of 200mA flows to the LED.

How was it possible to considerably lower the brightness of the LEDs, as shown in the right photo in Fig. 1, when the temperature increases? The reason is explained below using Fig. 3.

The chip-type prototype POSISTOR was mounted on the LED demonstration board. The POSISTOR is designed so that the resistance value will become 0.5ohm at a temperature of 25°C. The POSISTOR is a ceramic PTC thermistor with a positive temperature coefficient. Its resistance value increases sharply by more than 1,000 times at the designated temperature. The left-side graph shows the resistance temperature characteristics of this prototype POSISTOR. As the 3.0ohm fixed resistor (R) and the POSISTOR ( $R_{PTC}$ ) are connected in series on the LED demonstration board, the changes of the LED current according to the temperature of this composite resistance ( $R+R_{PTC}$ ) are also shown on the right-side graph.

This series composite resistance determines the current ( $I_{LED}$ ) that flows to the LED. As shown in the right graph, the LED current is almost constant at about 200mA when the temperature is less than

40°C. The LED current is sharply reduced when the temperature increases to more than 40°C. When the temperature is 80°C, the LED current will become 40mA or less.

The overheat protection mechanism can be constructed by simply adding the POSISTOR to a limit resistor that determines the amount of current that flows to the LED. Even if the LED is exposed to a high temperature because of some reason, using this mechanism will prevent the LED lights from continuous heat buildup due to high brightness. This mechanism is very simple, but can avoid worst-case scenarios that can cause an LED device to emit fumes or catch fire. As a result, complicated temperature sensing functions, logic for determining the state, and control functions for LED current are no longer required.

Furthermore, when the POSISTOR is used, the current is not shut down completely when the temperature becomes

high. Some amount of current is still supplied to the LED, for example, approximately 40mA is supplied at 80°C. Therefore, the POSISTOR is ideal for applications like lighting devices that are likely to create even more dangerous situations if the light is suddenly shut down completely.

In general, the allowable current for ambient temperature is clearly stated in the specifications of LED devices. This specification is provided because LED devices will degrade faster and the life of LED devices will be shortened if they are used at a current exceeding the allowable current value. When the LED current can be restricted, as shown in the right graph in Fig. 3, controlling the current can be done in accordance with the allowable current curve of the LED device.

The above example is an application of the prototype POSISTOR. At present, Murata is endeavoring to develop POSISTOR products with optimal characteristics for use in LED lighting devices. This includes POSISTOR with optimal shape, resistance value, and temperature at which the resistance value increases.

**Using Available POSISTOR Parts**

A function similar to the one previously shown using the LED demonstration board can be implemented by using an already available POSISTOR and an LED driver IC. Fig. 4 shows the conceptual diagram of this circuit.

When the LED driver is equipped with a temperature sensing port, as shown in the left-side circuit, an overheat protection function can be easily implemented by using the temperature characteristics of the series composite resistance of the fixed resistor and the POSISTOR. Fig. 5 explains why this is possible.

The graph on the left side shows the re-

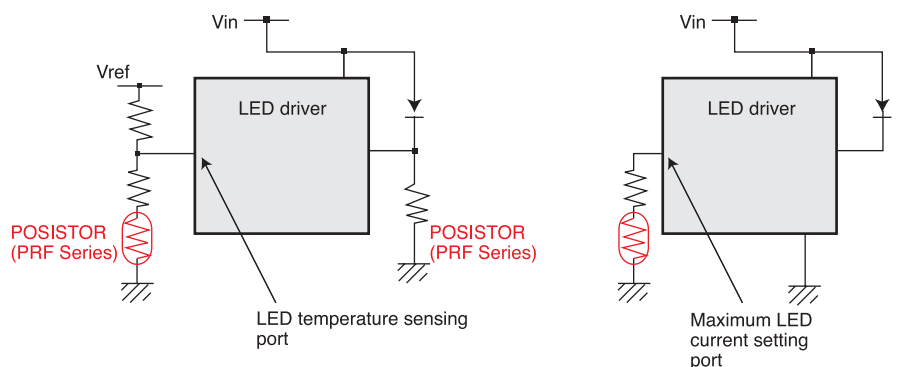


Fig. 4: Combination of chip POSISTOR PRF Series and LED driver

**Parts for LED Devices**

sistance temperature characteristics of the already available chip POSISTOR PRF Series. The resistance values at 25°C for all parts are 470ohm, but the temperature at which the resistance value sharply increases varies depending on parts. When this PRF Series ( $R_{PTC}$ ) and a 3.0kohm fixed resistor (R) are connected in series, the composite resistance ( $R+R_{PTC}$ ) will become 3.47kohm at 25°C.

The graph on the right side shows the voltage ( $V_{out}$ ), which is divided by 10kohm fixed resistance ( $R_d$ ) by applying 3.3V of constant voltage ( $V_{ref}$ ) to the series composite resistance of the parts in the PRF Series. The voltage of all parts at about room temperature is more or less constant at about 0.85V. However, the voltage of all parts sharply increases at the temperature specified for each part. For example, when the PRF Series “BE” character part is used, its  $V_{out}$  becomes 2.75V when the temperature reaches 100°C. In the case of the “BC” character part,  $V_{out}$  becomes 2.75V at 120°C.

The LED driver receives such voltage fluctuations as temperature information. For example, it is possible to implement a function to shut down the LED light if the received voltage exceeds 2.75V. The advantage of using the POSISTOR to achieve this function is that it can make the driver side circuit and the logic extremely simple. Normally, in such over-heat detection circuit, the temperature that must be detected by a sensor device may

**Table 1: Specifications of chip POSISTOR PRF Series**

Part No.	Resistance value	Sensing temperature 1 at 4.7k ohm	Sensing temperature 2 at 47k ohm	Maximum operating voltage	Operating temperature range
PRF18AS471QB5RB	470ohm±50%	145 ± 5°C	-	32Vdc	-20~ + 160°C
PRF18AR471QB5RB		135 ± 5°C	150 ± 7°C		-20~ + 160°C
PRF18BA471QB5RB		125 ± 5°C	140 ± 7°C		-20~ + 150°C
PRF18BB471QB5RB		115 ± 5°C	130 ± 7°C		-20~ + 140°C
PRF18BC471QB5RB		105 ± 5°C	120 ± 7°C		-20~ + 130°C
PRF18BD471QB5RB		95 ± 5°C	110 ± 7°C		-20~ + 120°C
PRF18BE471QB5RB		85 ± 5°C	100 ± 7°C		-20~ + 110°C
PRF18BF471QB5RB		75 ± 5°C	90 ± 7°C		-20~ + 100°C
PRF18BG471QB5RB		65 ± 5°C	80 ± 7°C		-20~ + 90°C

vary depending on the lighting device. It could be because of the effect of the temperature difference between the LED and the sensor device and the difference in the thermal dissipation mechanism of the components around the LED. To cope with these differences in temperature that have to be detected, a different part of the POSISTOR can simply be used. The same threshold voltage setting and temperature detection logic at the driver side can be set for all circuits. Since there are no modifications required at the detection circuit side, users can save on labor and time during the design process.

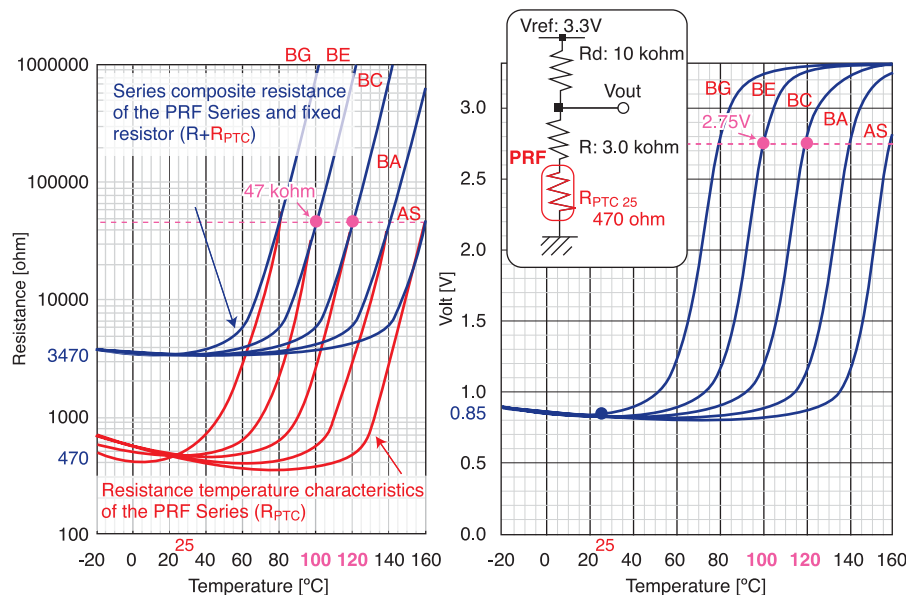
Furthermore, if voltage changes, as shown in the right-side graph, can be directly used for controlling the LED cur-

rent, it is possible to implement the over-heat protection function, which quickly reduces the LED current at the desired temperature, without completely shutting down the light. This was explained through the LED demonstration board earlier.

If the LED driver is equipped with an LED maximum current setting port, as shown in the right-side circuit of Fig. 4, the resistance value changes, as shown in the left-side graph of Fig. 5, can be directly used for reducing the LED current. This same protection function can be implemented using the already available chip POSISTOR PRF Series instead of a newly developed POSISTOR such as the ones used in the LED demonstration board.

Table 1 gives a list of specifications of the chip POSISTOR PRF Series.

Some LED lighting devices have already adopted the method to use the PRF Series, which was introduced in this article, combined with an LED driver IC. In this manner, Murata intends to contribute toward making LED lighting devices less expensive and assure their safety by means of a simple overheat protection function, including the newly developed POSISTOR. Murata will continue to work together with LED lighting device and LED driver IC manufacturers to improve the usability of the POSISTOR and optimize its specifications.



**Fig. 5: Resistance temperature characteristics of the PRF Series and output voltage versus temperature**

**About This Article:**

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