

## High Brightness LED Lighting Solution

High brightness (HB) LEDs are energy-saving, cost-effective choices that enable the next generation of lighting applications. From architectural lighting and automotive lighting, to backlighting of displays and new consumer products like flash for camera phones or compact projectors, HB LED lighting usage continues to grow.

### Overcurrent Conditions

LED light output varies with the type of chip, encapsulation, efficiency of individual wafer lots and other variables. LED manufacturers use terms such as high brightness to describe LED intensity. HB LED drivers can either be linear or switching current supplies. Linear drivers are best suited when the supply voltage is slightly greater than the load voltage; they use resistors to limit the current. Switching supplies are often used for HB LED drivers as they are more efficient than linear supplies.

Generally, current sensing resistors provide the feedback to the current regulation controller in order to monitor the current fed to the HB LEDs. There is a simple and complete alternative design: TE PolySwitch polymeric positive temperature coefficient (PPTC) devices can limit the current through the LEDs, and provide the overtemperature protection for HB LEDs.

A PPTC device is a series element in a circuit, as shown in Figure 1. The PPTC device protects the circuit by going from a low resistance to a high resistance state in response to an overcurrent. This is called "tripping" the device.

Generally the PPTC device has a resistance that is much less than the remainder of the circuit and has little or no influence on the normal performance of the circuit. But in response to an overcurrent condition, the device increases in resistance (trips), reducing the current in the circuit to a value that can



be safely carried by any of the circuit elements. This change is the result of a rapid increase in the temperature of the device through I<sup>2</sup>R heating

### Overtemperature Conditions

Unlike traditional lighting, HB LEDs are very sensitive to heat. The PN junction should not be allowed to reach certain temperatures to ensure normal operating life and high reliability. Controlling the temperature of the HB LEDs has proven to be critical to their life span.

Since PolySwitch devices are thermally activated, any change in the temperature around the device will impact its performance. As the temperature around the device increases, less energy is required to trip the device and thus its hold current value decreases.

PPTC current limiting devices limit current and react to increases in temperature by changing from a low-resistance state to a high-resistance state. This temperature regulation offers overtemperature protection for the HB LEDs as well as aiding in limiting overcurrent.

Figure 1 illustrates TE's solution to help protect HB LED circuits. A surface-mount PolySwitch device will help protect the circuit against damage from overcurrent and overtemperature events.

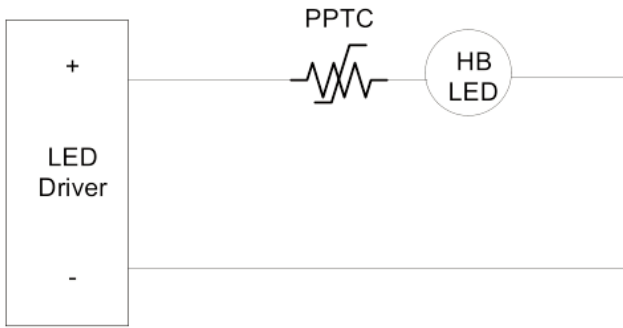


Figure 1 - Typical PPTC circuit protection design for HB LEDs.

### PolySwitch Technology Brief Summary

Under normal operating conditions, the heat generated or lost by the PPTC device to the environment is in balance at a relatively low temperature (for example at a temperature shown as Point 1 in Figure 2).

If the current through the device is increased while the ambient temperature is kept constant, the heat generated by the device increases and its temperature does the same. However, if the increase in current is not too large, all the generated heat can be lost to the environment and the device will stabilize at a higher temperature, such as Point 2 in Figure 2.

If instead of the current being increased the ambient temperature is raised, the device will stabilize at a higher temperature, possibly again at Point 2 in Figure 2. Point 2 could also be reached by a combination of a current increase and an ambient temperature increase.

Further increases in either current or ambient temperature or both will cause the device to reach a temperature where the resistance rapidly increases, such as Point 3 in Figure 2. This is referred to as the lower knee of the curve.

Any further increase in current or ambient temperature will cause the device to generate heat at a rate greater than the rate at which heat can be lost to the environment, thus

causing the device to heat up rapidly. At this stage, a very large increase in resistance occurs for a very small change in temperature. In Figure 2, this region of large change in resistance for a small change in temperature is illustrated between points 3 and 4, and is the normal operating region for a device in the tripped state. This large change in resistance causes a corresponding decrease in the current flowing through the circuit. The current is reduced to a safe level, helping to protect the circuit from damage.

Since the temperature change between Points 3 and 4 is small, this relation holds until the device resistance reaches the upper knee of the curve (Point 4 in Figure 2).

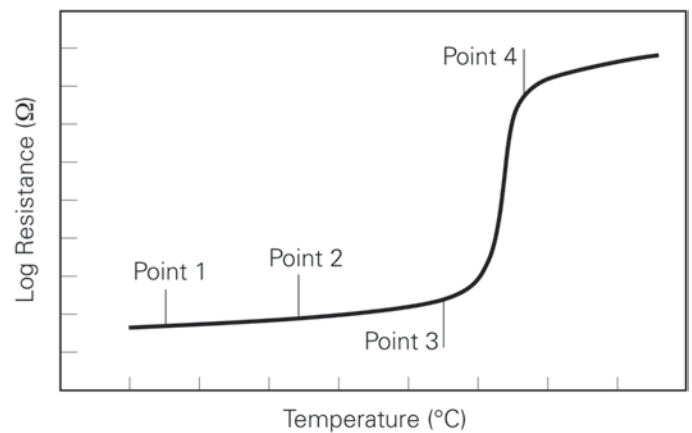


Figure 2 - Example of Operating Curve for PPTC Devices.

As long as the applied voltage remains at this level, the device will remain in the tripped state (remaining latched in its protective state). Once the voltage is decreased and the power is removed the device will reset and come back to a low resistance state.

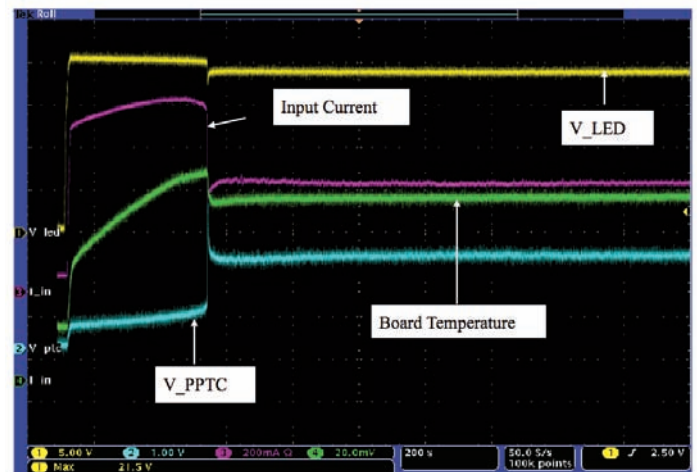


Figure 3 - The circuit status before and after PPTC protection devices tripping.

Figure 3 illustrates the circuit behavior prior and after the PPTC device trips to protect the HB LED. One can see that the current is reduced after the tripping event, helping reduce the board temperature. The voltage across the PPTC device, low before the trip event, reaches a higher value once the resistance of the device increases dramatically.

Resettable PPTC devices offer help in protecting against damage caused by both overcurrent and overtemperature faults in LED lighting applications.

Actual performance in specific customer applications may differ due to the influence of other variables. Customers should verify actual device performance in their specific applications.

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## Sources and additional information

Fundamentals of PolySwitch overcurrent and overtemperature devices can be found at:

<http://www.circuitprotection.com/catalog/fundamentals/PSWFundamentals.pdf>

Additional information on surface mount PolySwitch devices can be found at:

<http://www.circuitprotection.com/surface.asp>

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