MHP-TA RESETTABLE TCO DEVICE

For Lithium Battery Protection

Littelfuse PolySwitch MHP-TA circuit protection device's thermal activation and other advanced features help provide a cost-effective, space-saving method of overtemperature protection in today's thinnest consumer electronics devices.

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Introduced in the 1990s, the Lithium-Ion (Li-ion) battery immediately proved popular in both consumer and industrial applications due to its high energy density and small volume. Today it has become the favored battery choice for mobile devices. However, even as the high component density and performance of electronic products increases twofold every 18 months, in accordance with Moore's Law, the performance of the Li-ion battery increases only four to seven percent annually. Undeniably, this phenomenon is now causing a bottleneck in the otherwise rapid development of portable consumer products.

To maximize battery runtime in a form factor that is as thin as possible, designers are increasingly turning to large-surface-area, high-capacity, envelope-like Lithium Polymer (LiP) cells. High-capacity rechargeable LiP cells are frequently used in rapidly growing markets for the thinnest mobile electronics such as ultra-slim notebook PCs, tablets and smart phones. Meanwhile, traditional battery protection devices used in battery pack applications for lower-end feature phones often do not have high enough hold currents to meet the latest design requirements. As a result, manufacturers are increasingly challenged to find overtemperature protection devices that are ultra-compact yet compatible with the higher hold currents typically needed in LiP cell applications.

In response to these new battery technology requirements, Littelfuse has developed the MHP-TA series of ultra-low-profile resettable thermal cut-off (TCO) devices for lithium battery protection. The MHP-TA device's thermal activation and other advanced features help provide a cost-effective, space-saving method of overtemperature protection in today's thinnest consumer electronics devices.

New Battery Safety Challenges

Consumers' expectations of having high-energy in portable electronics, along with the ongoing trend towards larger screens on slimmer-profile products, have created demand

for LiP cells with a large surface area and capacities that can reach more than 4000mAh per cell. This high capacity not only increases the amount of active material in the cell that could cause a safety event, but the cell's large surface area also creates challenges in detecting a thermal event in the far edges of the cell. As such, designers prefer using safety devices with thermal cut-off temperatures below 90°C and that can shut down the cell well before cell damage or thermal runaway can occur.

When LiP cells are used in applications with higher power requirements, such as notebook PCs, the cells are often subject to higher discharge rates, high pulse currents and higher charge currents. For instance, the power boost function in some notebook computer applications can result in pulse discharge current as high as 20A for a few milliseconds. In addition, these higher discharge rates cause the cells to operate at higher temperatures which can damage the cell. This means that safety or cell performance may be compromised if adequate circuit protection is not provided.

Currently, very few protection solutions are available that offer a combination of low thermal cut-off temperatures, high hold-current ratings and a compact size. Additionally, existing PPTC (polymeric positive temperature coefficient) resettable devices are not always able to achieve the necessary combination of low cut-off temperature and high hold currents in a small size.

MHP-TA Technology

The MHP-TA (Thermal Activation) series is an extension of Littelfuse MHP (Metal Hybrid PPTC) technology, which combines a PPTC and a bimetallic circuit breaker in parallel. The MHP device's PPTC acts as a heater to keep the bimetal latched. The thermal cut-off rating of the device is determined by selecting bimetals with different open temperatures; typically 72°C to 90°C for the battery market. The device interrupts current when it detects a high cell temperature and shuts down the battery system before the battery overheats.

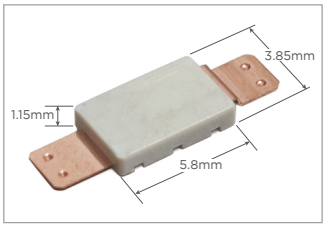

Figure 1. Typical dimensions of the compact MHP-TA device

The MHP-TA product line consists of two device series based on different levels of current carrying capacity. The low-current devices offer approximately 6A hold current at 25°C and high-current devices of approximately 15A. By offering two levels of carrying capacity in an ultra-low-profile package (L: 5.8mm x W: 3.85mm x H: 1.15mm), as shown in Figure 1, the MHP-TA device addresses the issue meeting high hold-current rating requirements while also providing a cost-effective, space-saving method of overtemperature battery protection in the latest generation of consumer electronics.

Figure 2 compares benefits of PPTC devices versus bimetals. By combining a PPTC and a bimetal in parallel, the MHP hybrid approach is able to maximize the advantages and minimize the disadvantages of each technology.

	Advantages	Disadvantages
Bimetal	Low resistance High operating current Good temperature sensing	Non-Latching Mechanical contact
PPTC	Latches No mechancial contact	Thermal derating size for operating current

Figure 2: Resettable MHP-TA devices offer the combined benefits of a PPTC and bimetal in a single, compact package

Bimetals consist of two metallic components having different thermal expansion coefficients that bend when subjected to a change in temperature. The advantages offered by bimetals are their low resistance at the point of contact, good current carrying capability and rapid response to changes in temperature; however, their disadvantage is not having good latching characteristics. Therefore, the advantage of the PPTC is its ability to act as a heater to provide latching, which keeps the MHP-TA device tripped during an abnormal event.

As shown in Figure 3, during normal operation of the MHP-TA device, current passes through the bimetal contact due to its low contact resistance. In the case of an abnormal event, the device reacts to the rise in cell temperature, causing the bimetal contact to open at the specified temperature and its contact resistance to increase. At this point, the current shunts to the lower-resistance PPTC, which acts as a heater and helps keep the bimetal protector open and in a latched position until the fault is removed. Figure 4 shows the temperature characteristics of a typical MHP-TA device with a 77°C thermal cut-off rating.

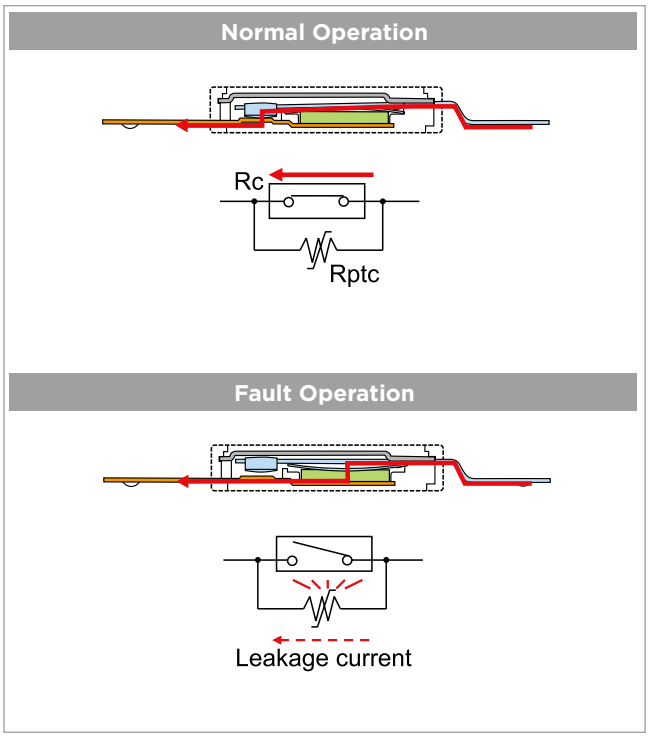

Figure 3: MHP-TA device principle of operation

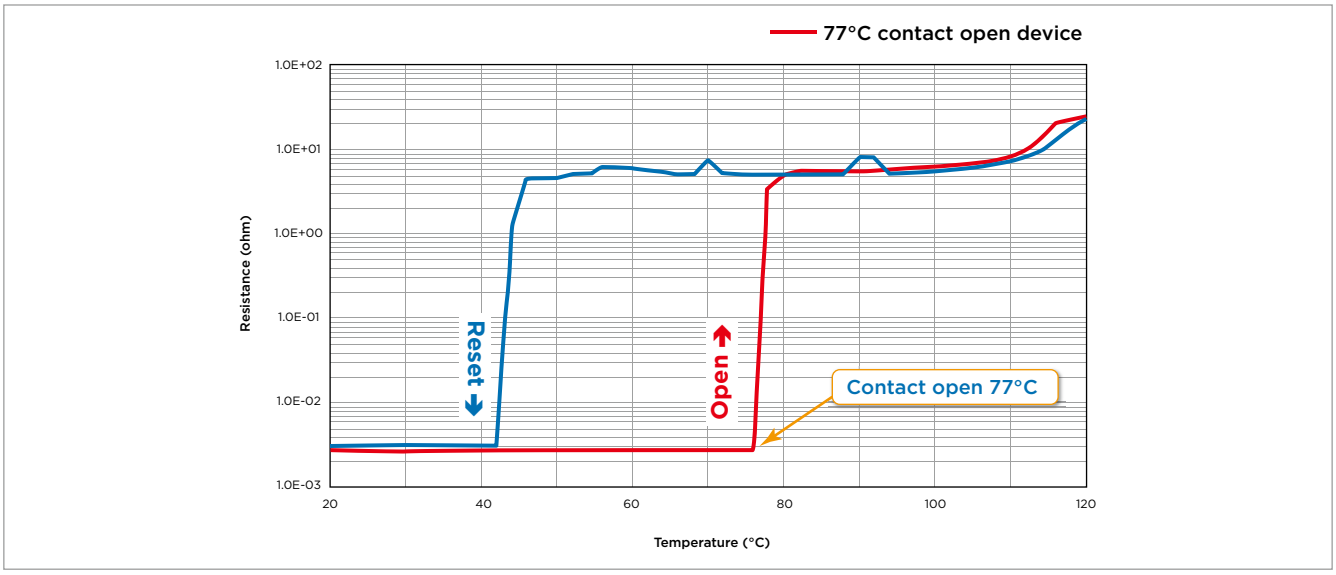

Figure 4: MHP-TA device's resistance vs. temperature characteristics

Typical Battery Application

Figure 5 shows a schematic of a typical battery pack application for the MHP-TA device. Such packs typically include an active overvoltage, undervoltage and overcurrent detecting safety circuit (IC and MOSFETs) as the primary pack protection, while the MHP-TA device is used as protection on the cell. Figure 6 shows an application of MHP-TA with a LiP cell.

Although the semiconductor circuitry in this application is considered reliable, there are conditions under which failure of the primary protection may occur, such as excessive electrostatic discharge, high temperature or oscillation during a short circuit condition. In these cases, the MHP-TA device helps provide cell overtemperature protection on charge and discharge.

The MHP-TA device's very low resistance also helps overcome the added series resistance introduced by the MOSFETs, and the device's trip temperature helps provide protection against thermal runaway in the case of an abusive overcharge. Unlike surface-mount devices, the MHP-TA is welded to the cell body, which helps improve heat transfer from an overheating cell to the MHP-TA device for faster thermal sensing.

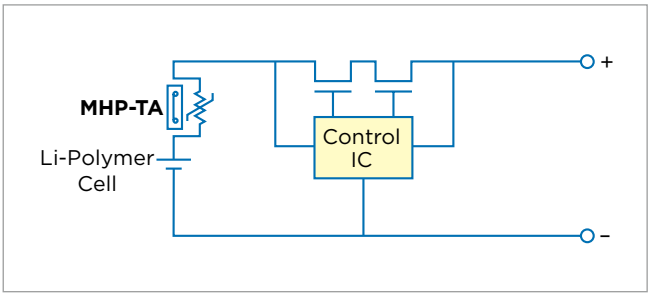

Figure 5: Typical battery pack design using the MHP-TA device

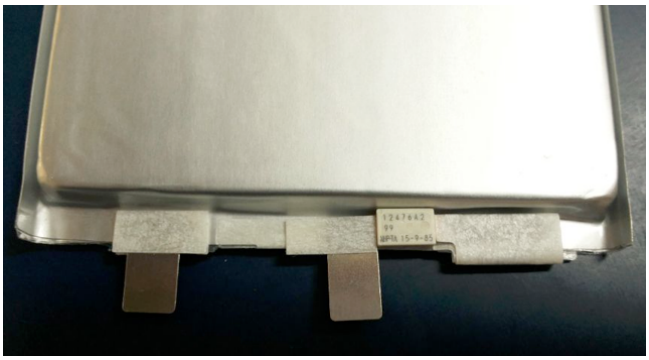

Figure 6: Typical application showing the MHP-TA device connected to the positive terminal of a Li-Polymer cell

MHP-TA Device Product Selection

Nine devices comprise the MHP-TA product line. The MHP-TAM6 series offers lower current carrying capacity (approximately 6A of hold current at 25°C) and the MHP-TAM15 series offers a higher current carrying capacity (approximately 15A of hold current at 25°C). The product line provides multiple activation temperature ratings (72°C, 77°C, 82°C, 85°C, and 90°C) that can be selected for specific battery chemistries or usage profiles.

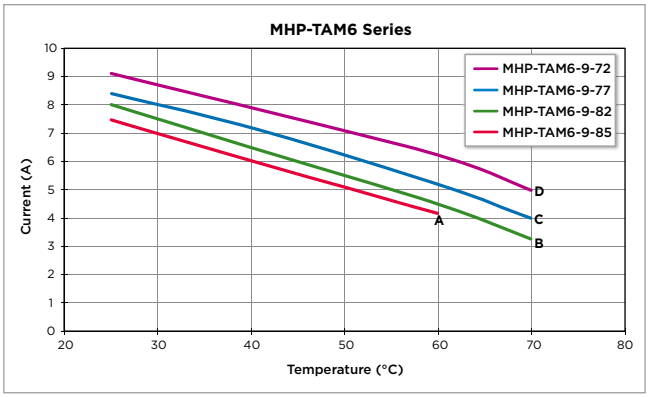

Figure 7: Typical hold current vs. temperature of the MHP-TAM6 series

Figures 7 and 8 show the typical hold currents of an MHP-TAM device at different ambient temperatures. Since the MHP-TA devices are TCOs, device selection should start with the required thermal cut-off temperature, while also keeping in mind the hold current requirements of the application. Due to thermal derating, the hold current level at higher temperatures, such as 60°C, should also be considered during application design.

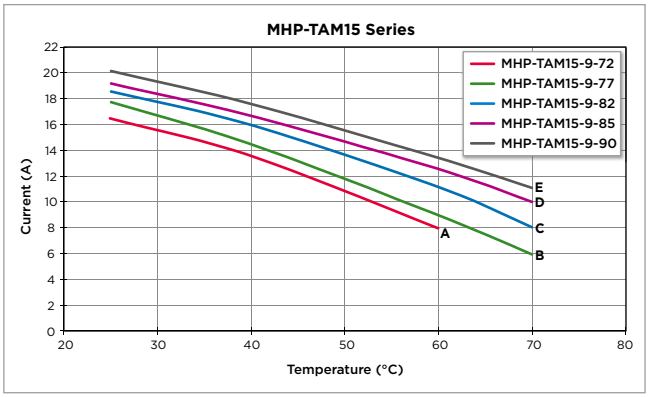

Figure 8: Typical hold current vs. temperature of MHP-TAM15 series

Summary

Keeping pace with the ongoing trend in consumer electronics of using high-capacity, large-format Lithium Polymer cells presents battery designers and manufacturers with a number of challenges. The MHP-TA device addresses these issues by offering the following benefits:

- Provides reliable, resettable overtemperature protection
- Capable of handling the higher voltages and battery discharge rates found in high-capacity LiP and prismatic cell applications
- Compact size and thin form factor facilitates circuit protection in compact battery pack designs

The thermally activated MHP-TA device helps provide resettable overtemperature protection while utilizing the PPTC device to act as a heater and to help keep the bimetal latched until the fault is removed. An effective TCO solution for helping protect the high-capacity LiP and prismatic cells found in tablets, ultra-thin notebook PCs, smart phones and other slim portable electronics, the MHP-TA device offers the added design flexibly of being available in multiple activation temperature ratings and in two levels of current ratings.