

Miniaturized Overtemperature Protection Allows Users to Safely Enter the Metaverse

WHITE PAPER



Bourns® SC Series
Miniature Resettable
Thermal Cutoff (TCO)
Device



Bourns® AC Series
Miniature Resettable
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INTRODUCTION

The lines of distinction between science fiction and science reality are blurring with the emergence of the Metaverse. This simulated digital world is the culmination of some of the latest trends in cutting edge technology. Extended reality (XR), artificial intelligence (AI), social media (Facebook, now Meta), cryptocurrencies, non-fungible tokens (NFTs) and blockchain are all converging to form this new sphere. In December 2021, Bloomberg Intelligence forecasted “Metaverse may be \$800 billion market” with a compound annual growth rate of 13.1 %.¹



METaverse KEY COMPONENTS

One of the key components for users to enter the Metaverse is the headset. The headset is the vehicle used to stimulate the wearer’s senses and introduce the various realities available in the Metaverse. Extended reality or “XR” is the umbrella term for the different systems employed within the Metaverse, where Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR) can also be part of the experience. For an evermore immersive experience, headsets are adding features such as greater display resolution, wider field of view and refresh rates, low latency and high megapixel video capability, and LIDAR sensors. For comfort, headsets can have built-in cooling and heating systems as well as long life lithium-ion battery packs.

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THE POWERING OF THE XR HEADSETS

The ability to power such high-end devices in ultra-thin form factors is the result of the steady evolution of the lithium-ion battery pack. The packs that first arrived on the market in the early 1990s have continued to improve with the development of new cathode, anode, electrolyte and separator materials. While lithium-ion battery technologies may not follow Moore's Law, they demonstrate a relentless progression in improving energy capacity, power delivery and life span while costs have continued to decrease. XR headsets are now integrating some of the latest high-energy density, lightweight lithium-ion cells.

LITHIUM-ION CELL HAZARDS

The basic function of the lithium-ion cell is to transform chemical energy into electricity. The individual lithium-ion cell is comprised of an intercalating lithium compound cathode, a carbon based (typically graphite) anode as well as a liquated or gel-type electrolyte with lithium salts through which ions travel. Finally, a polymer separator is employed to act as an internal insulator to the electrons. This separator element plays a critical role in cell safety by ensuring there is no physical contact between the cathode and anode.

The lithium-ion separator layers have evolved from simple single layer sheets to multilayer sheets with shutdown features. However, they alone cannot ensure complete cell safety. That's because the cell is constructed with materials that are flammable and degradable, whereby mechanical and electrical shocks can lead to thermal runaway. Another factor is that lithium-ion cell materials that are stable at lower temperatures start to break down when temperatures exceed 130 °C. If a cell starts to enter thermal runaway, the results can be catastrophic. Thermal runaway is a highly exothermic, self-propagating process that results in the venting of toxic and highly flammable gases and releases significant energy in the form of heat, typically greater than 1000 °C.

LITHIUM-ION CELL SAFETY

While lithium-ion pouch cells boast many desirable features such as low cost, ease of large-scale manufacturing, lighter non-universal sizes and high-energy densities, the technology still has the same limitations of other types of lithium-ion cells. The requirement for protection circuits to maintain the voltage and current within safe limits is one of the primary limitations of a lithium-ion battery. Considering such obvious hazards, cell designers take a multi-layered approach to protecting against various potential hazards. As XR headsets are in direct contact with the user's body, enhanced safety is paramount.

Mini-breaker thermal cut-off (TCO) devices are optimal solutions in the protection architecture that is being increasingly used in lithium-ion battery cell arrangements. TCO devices are designed to provide accurate and repeatable overcurrent and overtemperature protection.

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EFFECTIVE BATTERY PROTECTION SOLUTIONS

Meeting the changing protection demands in next-generation lithium-ion battery packs has led to the evolution of TCO technology as well. Today's TCO devices combine two common circuit protection technologies, a PTC device and a bimetal switch. Figure 1 below provides a simple schematic of the construction of a TCO. The two terminals (arm terminal and base terminal) are connected in a normally closed position to allow current to flow through the device. The contact point between both terminals serves a critical function in supporting high precision contact resistance, which can be as low as 1 mΩ.



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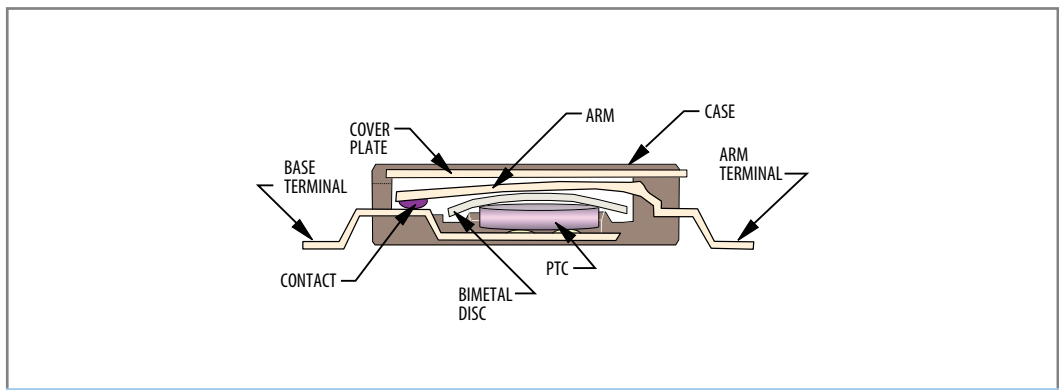


Figure 1 - Construction of Bourns® Mini-breaker TCO Device

Under normal conditions, current flows through the arm terminal, down through the very low resistance contact point and out through the base terminal (Figure 2).

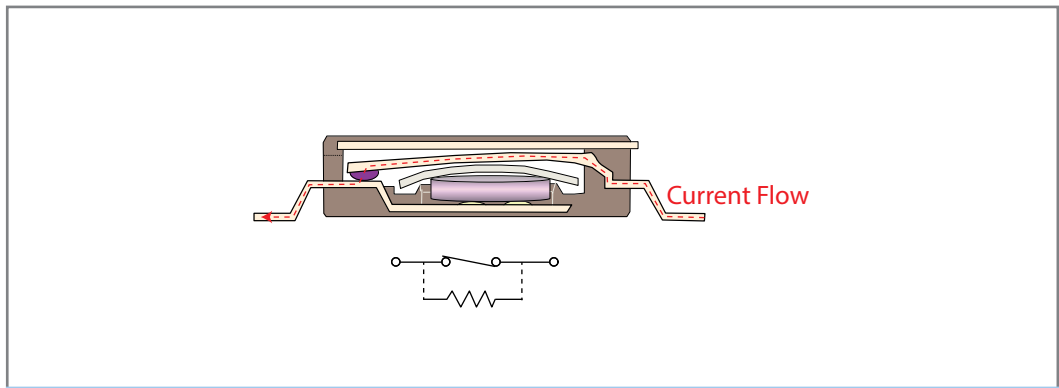


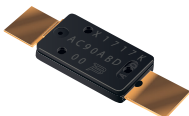
Figure 2 - Miniature TCO in the Normally Closed Position

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EFFECTIVE BATTERY PROTECTION SOLUTIONS (CONTINUED)



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The TCO device can be triggered by either an increase in the environmental temperature or by excessive current flows. Once the trip temperature has been reached, the bimetal disc flexes, and this motion causes the arm to open (see Figure 3). When the bimetal disc causes the arm to open, current flows through the bimetal disc and into the PTC device. This current causes the PTC device to act like a current-limiting heater, which provides sufficient heat to keep the bimetal disc flexed and the arm open. The combination of the bimetal disc and the PTC device prevents oscillating opening and closing of the TCO arm. Instead, this design allows the arm to remain open until a lower and safer temperature level is reached (between 40 °C and 10 °C below the lower specification limit of the TCO), at which point the arm will reset.

As part of UL 60730 testing, the opening and closing mechanisms of most Bourns® miniature TCO devices are tested up to 6000 cycles.

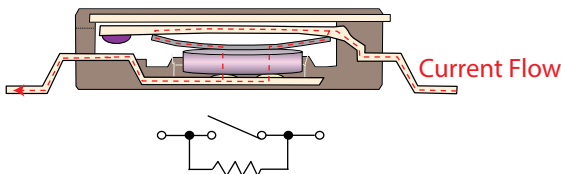


Figure 3 - Illustration of Mini-breaker Device Triggered Open

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XR HEADSETS USB CHARGING CABLES

As XR headsets are often charged while the user is wearing the device, additional safety precautions need to be considered for the charging cables. To allow both regular and fast charging of XR headsets requires the charging cables to be enhanced. The combination of small connector area, high pin count and higher power levels increases the potential risk of overheating in these new cables. Fast charging over such cables can even result in fire damage if pins are damaged, the outer shell body is damaged or foreign material and liquids enter the plugs.

For that reason, cable designers are also embedding Mini-breaker TCO devices within the charging cables themselves, (see Figure 4).



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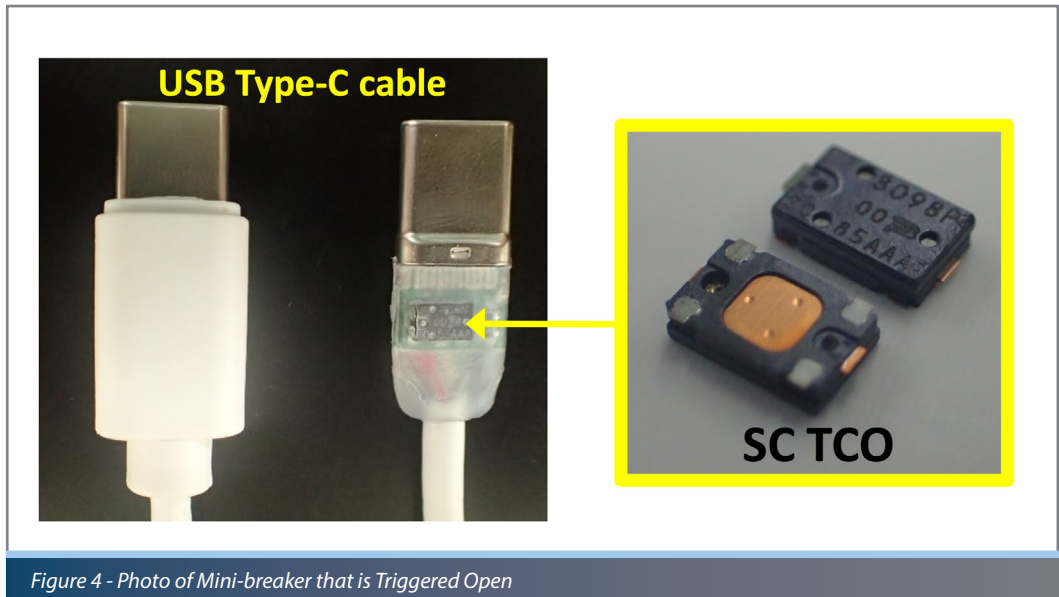


Figure 4 - Photo of Mini-breaker that is Triggered Open

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XR HEADSETS USB CHARGING CABLES (CONTINUED)



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TCO devices have been proven to protect cables from becoming damaged from overheating by acting independently of any controller. By placing the TCO device on the USB V_{bus} line, it can react to a cable overheating and then quickly cut the current and allow the cable to cool. This is rapidly becoming a popular solution. The performance of overheating cables with and without TCO device protection is demonstrated in Figure 5 below. The cable without the TCO device continues to overheat from the fault and the temperature increases to 100 °C. The cable with the TCO device almost instantly trips at a preset temperature so that the cable surface does not overheat.

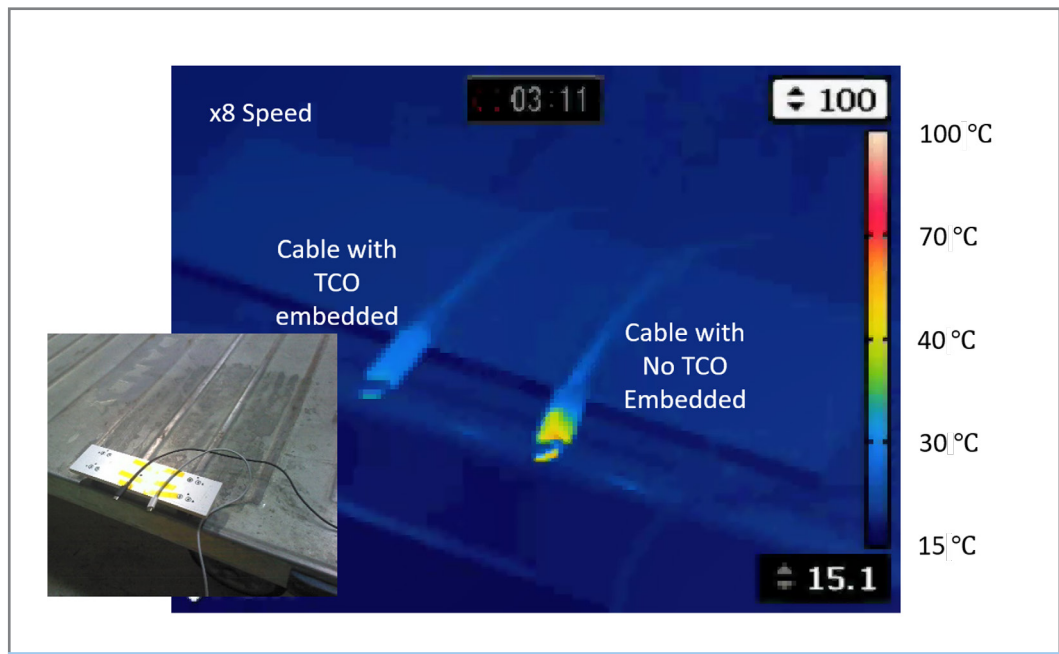


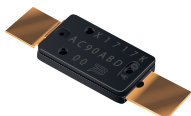
Figure 5 - Shown are USB cables under fault conditions.
(Cable on the left has TCO device protecting against overheating, the cable on the right has no protection)

In May 2021, the USB Promoter Group announced its USB Power Delivery Specification revision 3.1 ². This specification defined the delivering of up to 240 W over USB Type-C™ cables. This level of power will add to the considerations for further cable protection and protection devices must evolve to meet these challenges.

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CONCLUSION

XR headsets are the portals for users to step into the amazing experiences found in the Metaverse. These headsets are expected to evolve rapidly with more advanced features to help enhance a user's experience. Bourns' broad line of Mini-breaker TCO products have been used in more than six billion circuits, providing precise, reliable, long-life overtemperature protection. Bourns is actively working with some of the leading players in this new field to meet their protection requirements with some of the industry's most accurate, lightweight and miniature thermal protection devices available.

REFERENCES

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