

Overcoming Circuit Protection Challenges in Lithium Battery Cell Operated Electronics

Komatsulite™ Mini-Breakers APPLICATION NOTE



LC Series



HC Series



KCA Series



NR-C Series



NR-A Series

INTRODUCTION

Circuit protection has challenged engineers for decades. While there are good protection solutions available, it is rare that a new technology is introduced. Developers must select the right protection solution that will meet a constantly evolving range of applications. This is evidenced by the growing magnitude of portable electronics on the market that feature increasingly more advanced battery technology. Portability calls for battery packs to be smaller and thinner with increased battery cell density and greater inrush current handling capability than ever before. Given the continuing trend of reduced product and battery form factors, the size and rating of protection devices remains at the forefront of design requirements.

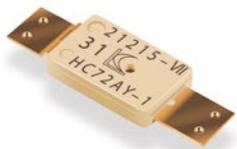
The range of portable electronics and other applications using rechargeable batteries presents a battery protection quandary. A more recent solution boasting a compact package and combined overtemperature and overcurrent protection for rechargeable battery applications is the mini-breaker by Komatsulite, a Bourns company. These mini-breakers are Thermal Cut Off (TCO) devices that combine a bi-metal switch and PTC in one package, providing several advantages over either technology on its own. The application, construction, operating characteristics, selection, and handling of Komatsulite™ mini-breakers will be discussed in this paper.

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MINI-BREAKER TECHNOLOGY OVERVIEW

In the consumer market, specific applications present additional circuit protection issues such as laptop personal computers, tablets, smartphones, and portable appliances such as vacuum cleaners. Electric bicycles, also called e-bikes, and controllers for automotive seats are additional examples of applications that may need an additional level of circuit protection to handle the overcurrent and overtemperature requirements of lithium battery cells. For instance, a Thermal Cut Off device or bi-metal switch on its own may not be able to effectively protect the batteries in these types of applications. A false trip could render a one-time fusing device inoperable, so a device with a reset mechanism is preferred. In such applications, a mini-breaker solution is a good option.

Mini-breakers incorporate existing technology in such a way to enhance their protection capabilities. Mini-breakers put a bi-metal switch and PTC in parallel to deliver the best features of both. Since a PTC latches and does not have a mechanical contact, it offsets the bi-metal switch's lack of latching providing a significant design advantage. Similarly, the bi-metal switch enhances the mini-breaker solution by providing a higher operating current. The temperature sensing capability and low resistance of the bi-metal switch are additional benefits gained by incorporating the mini-breaker into the hybrid device. With several temperatures available and 100 % in-line inspection of trip temperature, reset temperature, and impedance before shipping, Komatsulite™ mini-breakers offer reliable battery cell protection for multiple instances of overcurrent and overtemperature threats. Taking a look inside, Figure 1 illustrates that the mini-breaker is composed of a base terminal, PTC, bi-metal disc, base, arm terminal, arm, cover plate, contact, and cover.

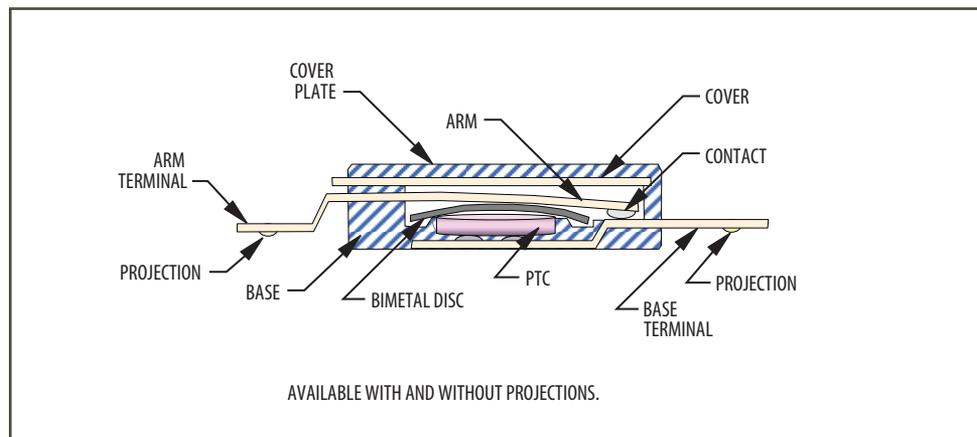


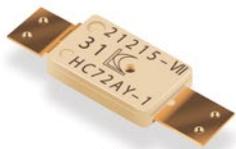
Figure 1. | Construction of the Komatsulite™ Mini-Breaker

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MINI-BREAKER TECHNOLOGY OVERVIEW (Continued)

During normal operation, the disc is curved downward such that a direct path is available for current to flow through from one terminal to the other. If the arm is exposed to rising temperatures or excessive current, the temperature of the bi-metal disc rises. Once the temperature of the bi-metal disc is heated to the trip temperature, the disc reverses such that its end point upward and lift the arm to the open position. In this tripped position, the path between terminals is physically removed and the current is shunted to the PTC. The heat in the PTC keeps the bi-metal disc open and latched. Once the overtemperature or overcurrent condition is removed, the bi-metal disc returns to its original shape and restores the path for current between the terminals. This operation occurs instantaneously, and the mini-breaker is stable with impedance as low as 1.5 mΩ and no more than 15 mΩ.

The Komatsulite™ mini-breaker also offers resettable activation enabling normal operation to resume immediately once the overcurrent or overtemperature condition is removed. Its design is resistant to false trips that can occur with typical thermal fuses. Furthermore, the mini-breaker does not require a reset circuit or power cycling, nor does it have to be replaced following tripping unlike standard fuses. Mini-breakers feature a very small footprint; they are compact enough to be placed directly across battery terminals to provide temperature and current protection instantaneously.

HISTORY OF MINI-BREAKER INNOVATION

Komatsulite has specifically developed its mini-breaker portfolio through its several-decade history to meet the overtemperature and overcurrent protection needs of battery-powered applications. The LC series was the first mini-breaker available with a trip temperature range of 72 - 85 °C. The low profile LC Series offers a reduced height option measuring 0.1 mm. The new HC series introduced mini-breakers with higher current capacity of 7 A to 12 A at 60 °C. The low profile design extended to the 2014 release of the NR-C low capacity series and NR-A high capacity series. In 2015, another application characteristic was addressed with the release of the corrosion-free KCA series.

Currently, mini-breakers are manufactured where the thermal cut off subassembly and nickel tabs are attached by welding. Future mini-breakers will feature welding of the nickel tabs only, which allows for automated inspection. The roadmap also includes a heat resistant surface mount package that provides the ability to handle reflow soldering three times. Komatsulite continues to increase the protection options for developers. The existing series of Komatsulite™ mini-breakers are shown in Table 1.

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HISTORY OF MINI-BREAKER INNOVATION (Continued)

Table 1. Ratings of Komatsulite™ Mini-Breakers by Series

Series	LC	HC	NR-C	NR-A	KCA
TEMPERATURE OPTIONS					
Trip Temperature (°C)	72, 77, 82, 85	72, 77, 82, 85, 90	72, 77, 82, 85	72, 77, 82, 85	72, 77, 82, 85
CONTACT RATING					
Voltage (V _{DC})	9	9	12	12	12
Current (A)	12	25	12	25	25
Number of cycles	6000	6000	6000	6000	6000
BREAKING CURRENT					
Voltage (V _{DC})	5	5	5	5	5
Current (A)	40	80	30	60	60
Number of cycles	100	100	100	100	100
MAXIMUM VOLTAGE					
Voltage (V _{DC})	28	28	28	28	28
Current (A)	5	25	12	25	25
Number of cycles	100	100	100	100	100
HOLDING VOLTAGE AT 25 °C FOR ONE MINUTE					
Voltage (V _{DC})	2	3	2	2	2
MAXIMUM LEAKAGE AT 25 °C					
Current (mA)	150	200	150	200	200
RESISTANCE AND SIZE					
Max. Resistance (mΩ)	15	5	15	5	5
Size (mm)	11.2 x 3.75 x 1.15	11.2 x 3.75 x 1.15	11.2 x 2.8 x 0.89	11.2 x 2.8 x 0.89	11.2 x 3.2 x .89
Size (in)	0.44 x 0.148 x 0.045	0.44 x 0.148 x 0.045	0.44 x 0.11 x 0.035	0.44 x 0.11 x 0.035	0.44 x 0.091 x 0.035

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DEVICE HANDLING RECOMMENDATIONS

Given the mechanical characteristics of the mini-breaker Thermal Cut Off device, certain precautions are essential in its handling. The terminals are made of thin copper alloy with right angle edges and should be handled with finger cots and tweezers. This helps avoid both finger injury and discoloration of the terminals from direct contact with the bare finger. The body of the mini-breaker is composed of plastic parts that can be damaged or result in increased resistance if clamped or dented with tools. Similar damage to the body can result from excess stress on the mini-breaker and body terminals. Regardless of whether the mini-breaker body is welded with direct welding or series welding, the selection of a suitable jig can help ensure there is no excess stress.

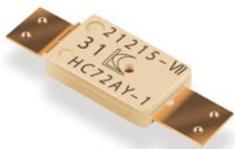
Komatsulite™ mini-breakers currently are not intended for a surface mount processing or for reflow soldering. Rather, resistance or laser welding are suggested for connecting the nickel tabs to the existing mini-breakers. For safety, the device must be used within the electrical rating specified in the data sheet. This helps ensure the switching and activation life cycle is not impacted and the mini-breaker arm remains robust. The mini-breaker should be mounted to the hottest area of the device to ensure it transfers heat effectively. Once mounted, the mini-breaker and body terminals should not move. Vibration and heat may cause damage to the mini-breaker body or an increase in resistance. The mini-breaker is intended for use in normal environments and should not be exposed to extreme conditions, temperatures, fluids, gases, or static electric charges.

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RELIABLE LONG BATTERY LIFE PROTECTION

Komatsulite is a pioneer in the development of mini-breaker technology. Designed to enable long battery life, these valuable Thermal Cut Off devices are available with a high current draw, and fast battery recharging cycle. Delivering a unique protection solution, mini-breakers combine a bi-metal switch and a PTC to enhance the features of both, thus providing a superior battery protection solution. The mini-breaker's hybrid nature allows it to effectively protect against overcurrent and overtemperature conditions simultaneously. Mini-breakers are known for their stability, enhanced allowable voltage and improved leakage characteristics. The low resistance and compact package make the Komatsulite™ mini-breaker an optimal alternative for battery protection in countless applications.

Komatsulite continues to expand its product line with the goal of maintaining the highest safety reliability based on quality ISO 9001, ISO 14001, and ISO 27001 certifications. Giving developers additional confidence, Komatsulite has a proven track record of having received no field returns with more than two billion devices shipped since 2007. As a Bourns company, Komatsulite™ mini-breakers are supported by decades of circuit protection technology expertise, superior customer service, and global distribution sales channel. For space-constrained portable electronics, mini-breaker Thermal Cut Off devices offer a robust and complete alternative for the protection of lithium cells in a compact, single package solution.

ADDITIONAL RESOURCES

Please contact your local Bourns Application Engineer or Bourns Sales Representative for additional information.

Visit Bourns online at:

www.bourns.com

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