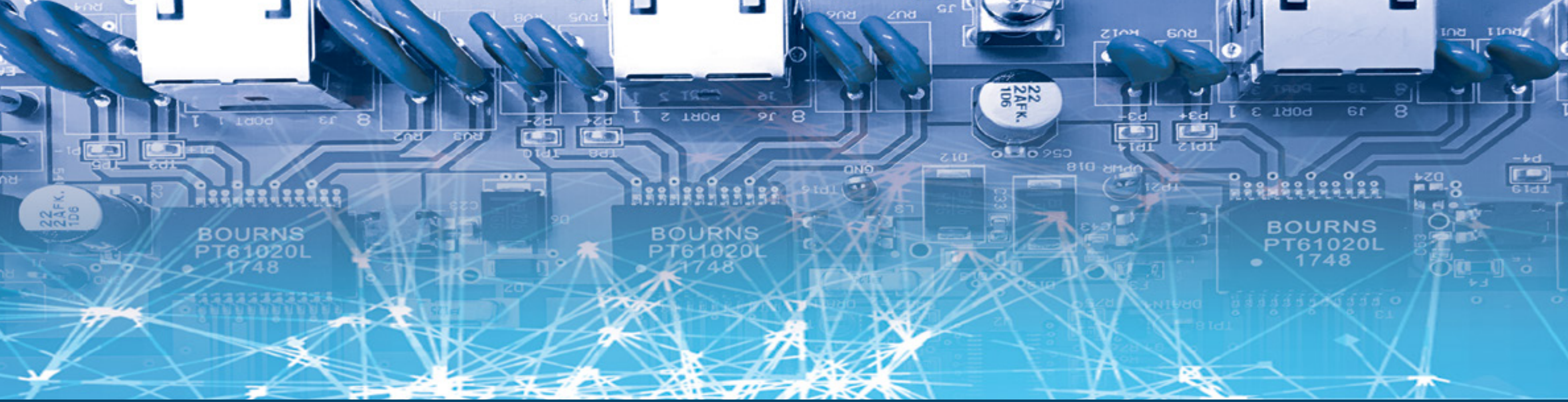


Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

WHITE PAPER

Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

INTRODUCTION

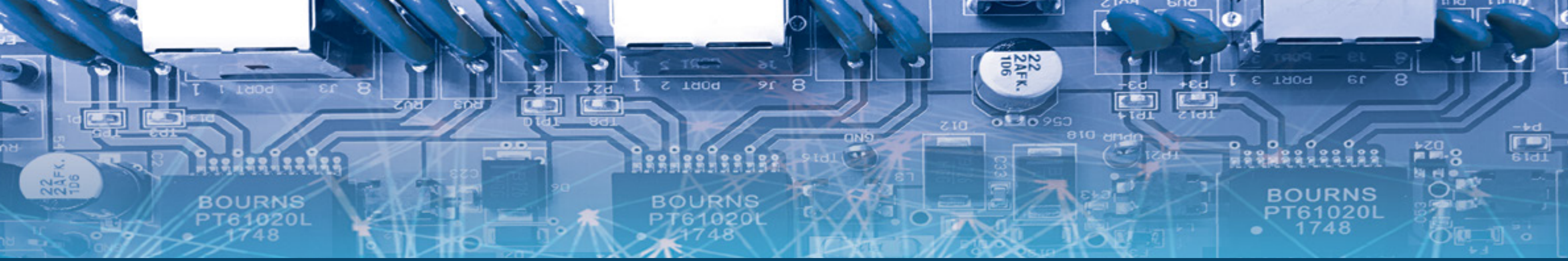
The evolution of electric vehicles is creating additional design challenges that call for new technologies to support reliable operation in many harsh environments, stringent adherence to increasing emissions regulations and enhanced solutions that meet ever-evolving standards. These challenges are made more complex with consumers' increased demand for in-vehicle comfort features.

The absence of the Internal Combustion Engine (ICE) as a source of heat means that electric vehicle designers need to look for other warming methods. The heating approach that they select must be able to provide a reliable and safe internal comfort system for passengers as well improve visibility with defrost functions, all while maximizing battery life and efficiency.

Systems used to heat steering wheels, seats, panels, sensors, mirrors and batteries are fast becoming standard equipment in most vehicle models today. In electric vehicles, these systems are typically powered by a heating element and/or electronic control device that is designed to provide a pleasant and comfortable surface temperature. For example, a long strip of a heating element can be placed beneath the material of the seat, and when turned on, an electric current heats the element, thereby heating the seat.

Because manufacturers are focusing on optimizing energy efficiency, this adds to the challenge of implementing effective "thermal management," which includes the likely replacement of conventional overtemperature protection solutions.

With the remarkable growth of advanced cabin comfort features, accurate temperature measurements and protection are critical design elements necessary to optimize energy efficiency and ensure driver and passenger safety in the event of a heating element malfunction. Primary and secondary overtemperature protection is required to safeguard against potentially dangerous short circuits that can cause damage to the vehicle and may harm a motorist or passenger.



Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

HEATER CIRCUITS

Heater designs come in a wide range of options because of the varying factors that must be considered, such as power rating, watt density and required surface temperature. For that reason, there is no fixed design for heater circuits. The method to control the temperature also varies greatly, from thermostat controls to more sophisticated controls using temperature sensors (e.g., NTC thermistors, PTC thermistors and RTDs), control ICs and switching MOSFETs. Some heater designers also choose to use temperature protection circuits to provide backup safety such as single blow temperature fuses and thermostats. This is particularly important for circuits that are in contact with the human body (e.g., seat heaters and steering wheel heaters). An example of such a circuit is shown below:

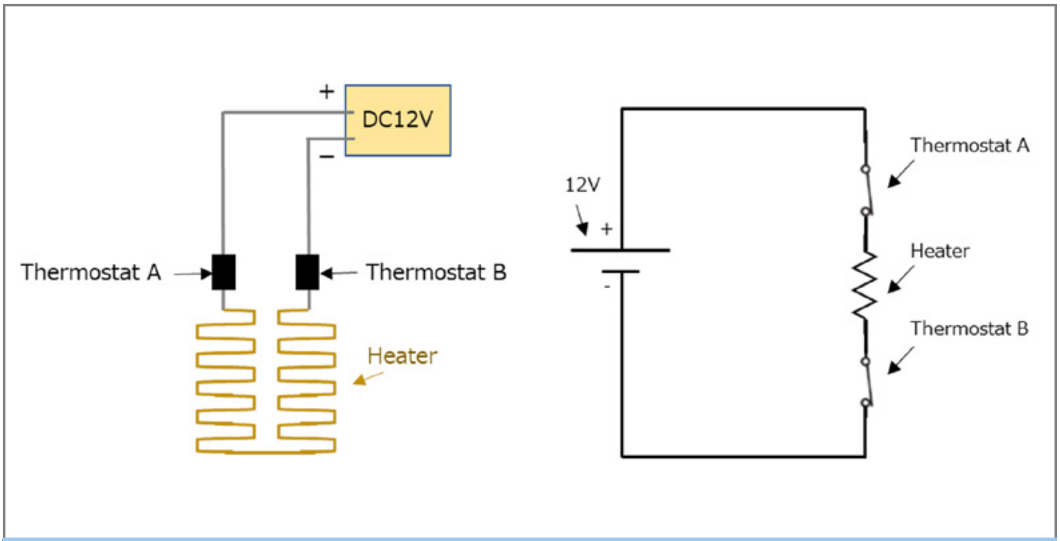
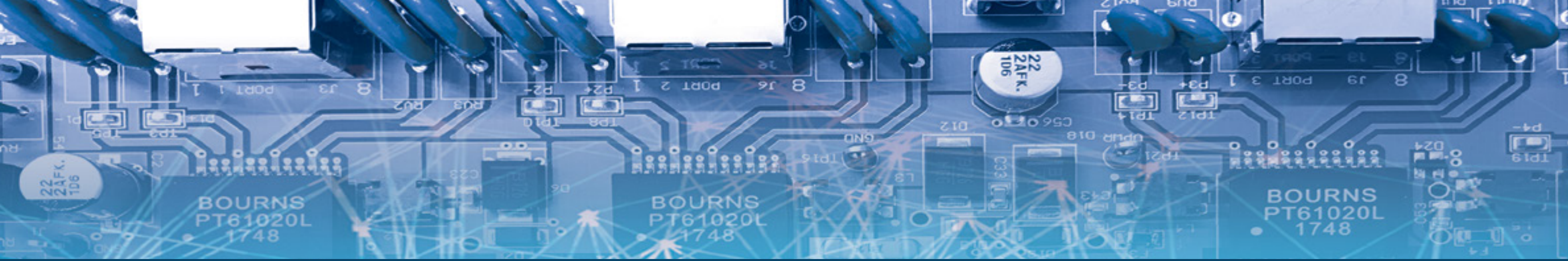


Figure 1 - Heater circuit using two thermostats
Thermostat A: temperature control Thermostat B: temperature protection



Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

HEATER CIRCUITS (Continued)

One of the main reasons that no ideal circuit architecture has been identified for heater designs is that there are potential risks with many existing solutions. Typically, heater control comes in the form of bimetal-based thermostats or more recently NTC thermistors and power MOSFETs. Circuits that utilize temperature sensors, control ICs and power MOSFETs can control the circuit at predetermined temperature levels, allowing them to be more energy efficient. However, MOSFETs in automotive applications may present some risks of thermal instability, and in worst case scenarios, can fail. Circuits that use single blow thermal fuses can suffer nuisance trips during assembly or in the field and can prove costly to replace. Using wired components instead of surface mount components may provide control and protection in hard to reach locations, but can be costly to assemble and maintain because of variances due to their manual installation.

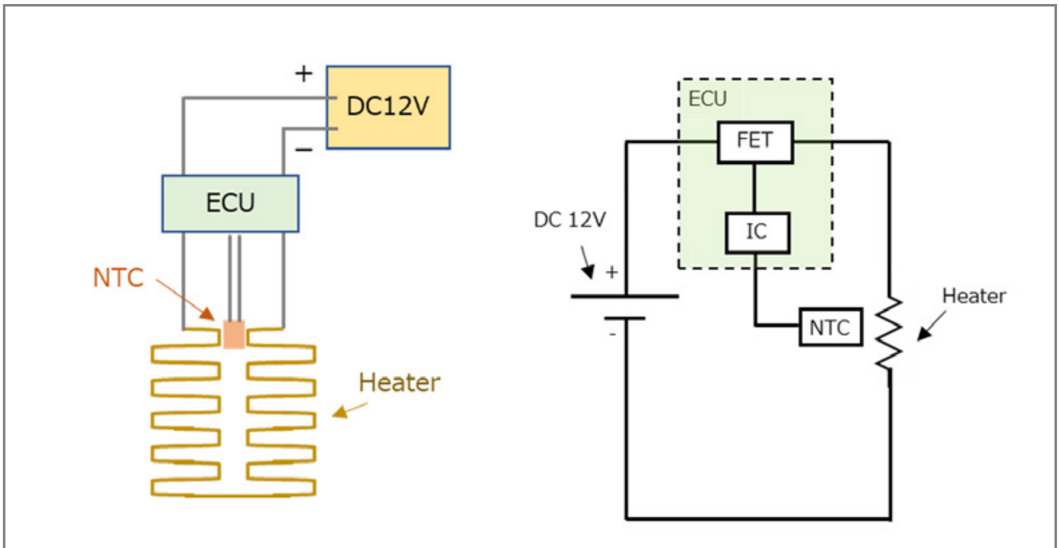
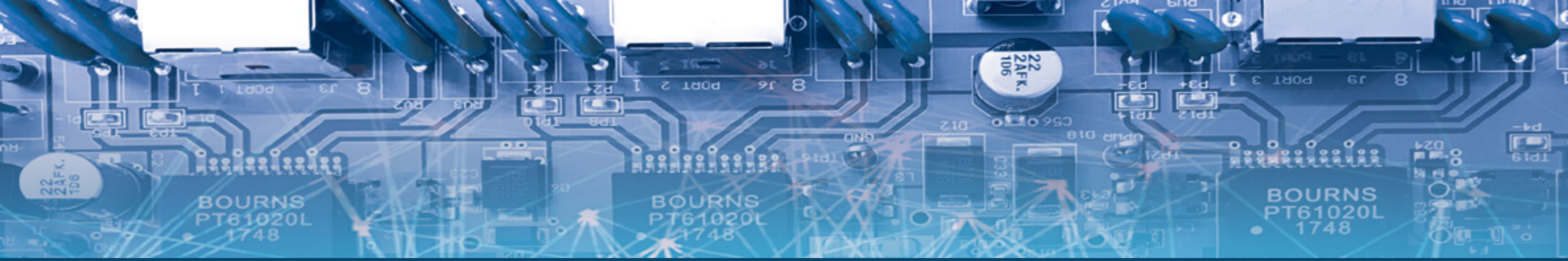


Figure 2 - Heater circuit using ECU + NTC
NTC: temperature monitoring No temperature protection device



Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

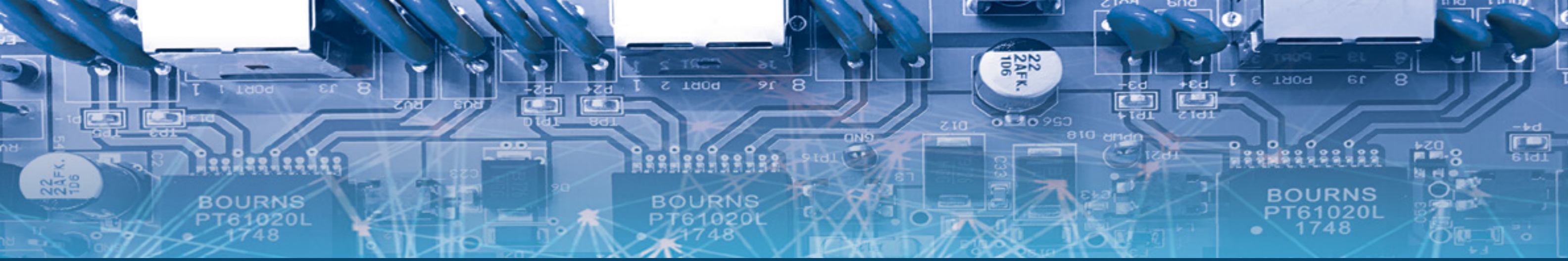
Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

BOURNS® MINI-BREAKERS PROVIDE OPTIMIZED HEATER PROTECTION

For almost 20 years, Bourns has been building mini-breaker Thermal Cut-Off (TCO) devices for the lithium-ion battery pack market, which are primarily used in notebook PCs and tablets. Because Bourns® mini-breakers are designed with lithium-ion protection in mind, they feature trip temperatures ranging from 72 ˚C up to 90 ˚C and offer a viable protection solution in a very small footprint. Leveraging the Company's overtemperature protection experience, Bourns is now applying its proven product development to the heater market. The new Bourns® SD and AD series mini-breakers help designers meet additional heater application requirements with a broader trip temperature range of 55 ˚C up to 150 ˚C. This is particularly applicable to the range of heater devices that require either low trip temperatures (e.g., cosmetic and low/medium risk medical heaters) and high trip temperatures (e.g., automotive heaters in electric vehicles).

For electric vehicle heating applications, these devices can be installed on the heating element and/or electronic control system to measure the element's temperature. When the temperature exceeds the threshold temperature, the Bourns® mini-breaker device triggers and protects by reducing the current flow and blocking further temperature increases. Then, the mini-breaker will remain in the off-state mode until the power is stopped. These tiny, resettable devices are ideal solutions for overtemperature protection on heater circuits that previously had no viable correct size or feature solutions.



Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

HEATER DESIGN BENEFITS OF MINI-BREAKERS

The Bourns® Model SD mini-breaker can be surface mounted either directly onto the flexible film heaters or onto the PCB of the heater control unit. If the design can accommodate, Bourns® Model SMD mini-breakers can be located close to the power MOSFET so the mini-breaker can also be used to protect that device. Attaching wires to a Model AD mini-breaker device is also a possible protection solution for wired heater assemblies. Resettable overtemperature protection in such miniature packages is a new and unique solution that offers many advantages to these applications. Some examples are outlined in Figures 3 and 4 below:

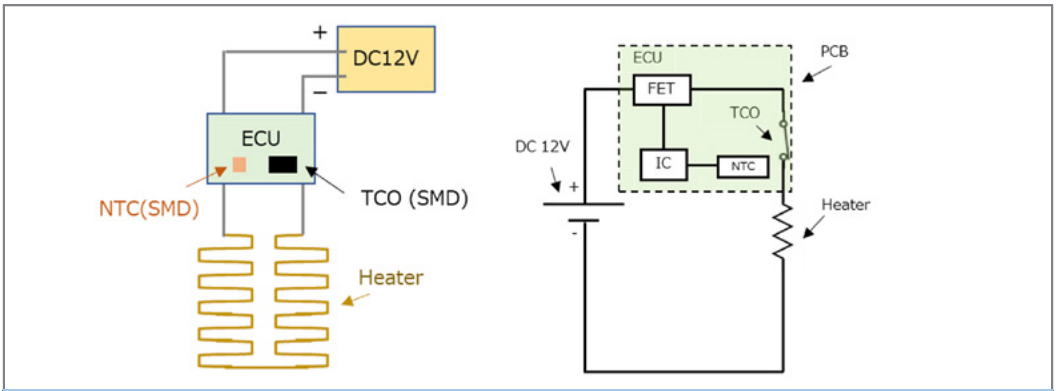


Figure 3 - Heater circuit module with SMD Mini-Breaker TCO (SD Series)

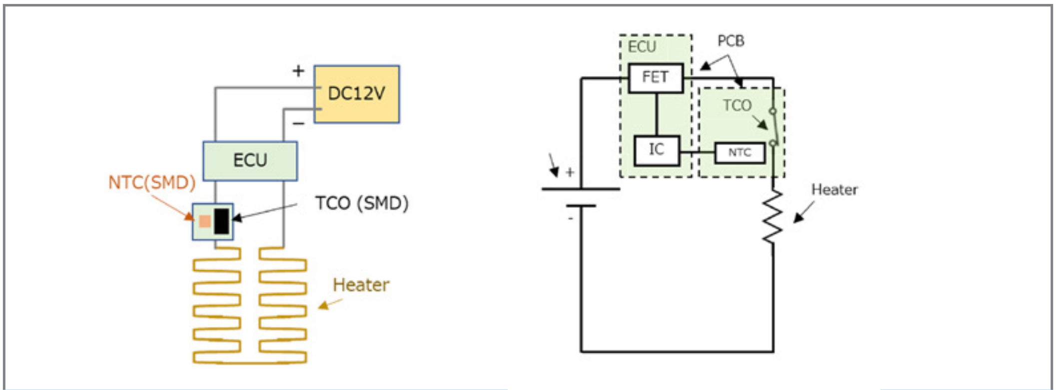
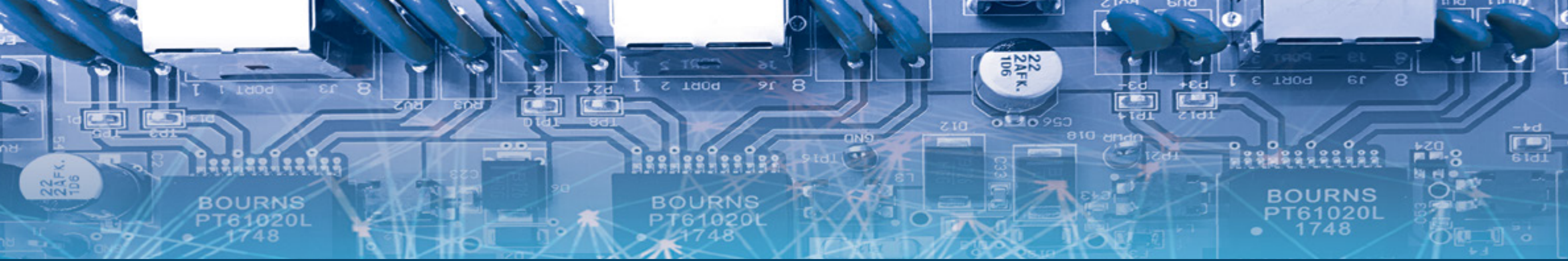


Figure 4 - Heater circuit using ECU + PCB with SMD Mini-Breaker TCO (SD Series)

Figure 3 shows how designers can use a single package with mini-breaker, IC, FET, NTC and other components; while Figure 4 illustrates a design with the mini-breaker and NTC thermistor separated. By integrating a mini-breaker into the protection circuit, it can both meet independent overtemperature protection requirements and help reduce the size of the heater control unit. Bourns' latest AD and SD series mini-breakers have been tested to withstand up to 10,000 cycles compared to the traditional 6,000 cycles used in lithium-ion battery applications.



Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

EFFECTIVE EV HEATER PROTECTION SOLUTIONS

Bourns offers a range of proven mini-breaker TCO devices. Demonstrated to protect against overtemperature conditions, Bourns® mini-breaker TCOs are a combination of two common circuit protection technologies: a PTC and a bimetal switch. As one of the leading suppliers of TCOs, Bourns has perfected its precision metal stamping, plastic injection molding and high-end assembly processes, making these ubiquitous technologies increasingly effective protection solutions. Figure 5 below provides a simple schematic of the construction of a mini-breaker. 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.

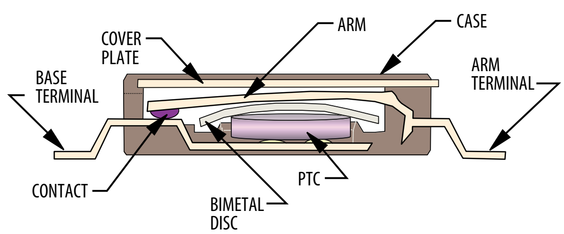


Figure 5 - Construction of Bourns® Mini-breaker TCO device

Under normal conditions, current flows through the arm terminal, down through the very low resistance contact point and out through the base terminal (Figure 6).

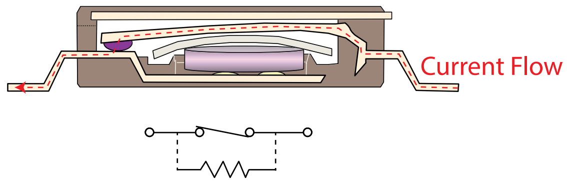
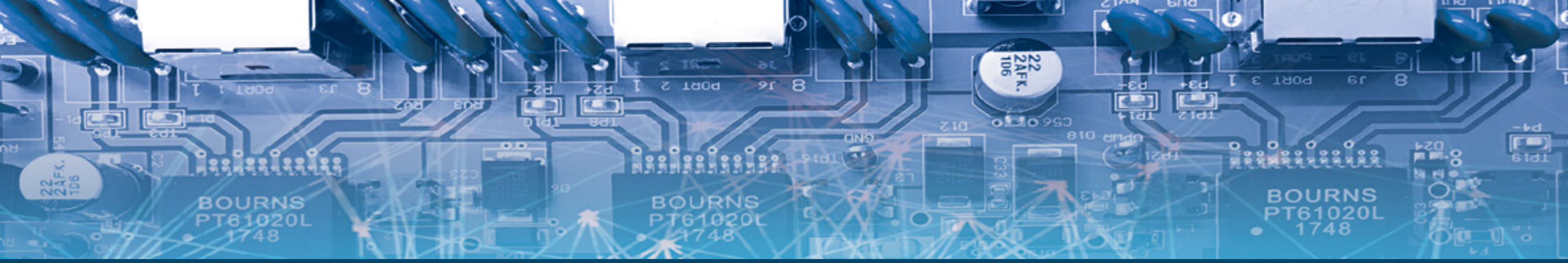


Figure 6 - Miniature TCO in the normally closed position



Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

EFFECTIVE EV HEATER PROTECTION SOLUTIONS (Continued)

The mini-breaker 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 7). 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 mini-breaker 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 mini-breaker), at which point the arm will reset.

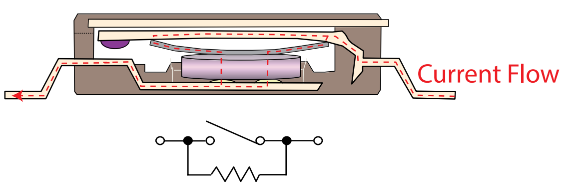
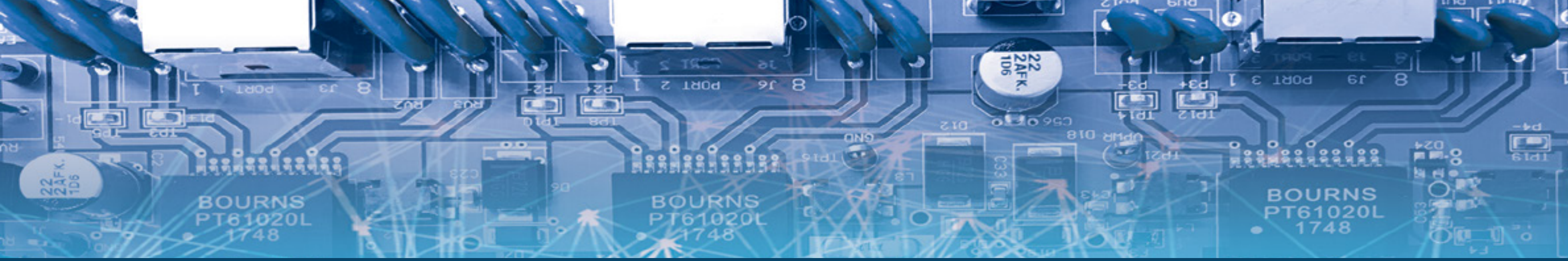


Figure 7 - Illustration of mini-breaker device triggered open

Specifically, for use in vehicle applications, Bourns has released its automotive grade Model SD and AD series miniature thermal cut-off devices. They are designed to provide temperature accuracy and excellent cycling capability in a compact package optimized for heater applications. These devices offer effective control of abnormal, excessive current virtually instantaneously, up to rated limits.



Employing Effective Automotive Heater Thermal Management Protection Using Mini-Breakers

Bourns® AD Series Mini-breakers

Bourns® SD Series Mini-breakers

CONCLUSION

With the expected rapid expansion of the electric vehicle market, driver and passenger safety will continue to be a top priority. And, there does not seem to be any end to the trend of increasing power density and miniaturization of electronic circuits. A key safety component will be effective thermal management design, which is vitally important in the development of highly accurate and robust temperature measurement systems, especially for electrification.

Therefore, efficient performance of heater systems within the vehicle will need proper overtemperature protection to help ensure reliable and safe performance regardless of excessive environmental conditions. The AD and SD series mini-breakers are some of the smallest overtemperature protection devices to be launched in the market. Tested by Bourns to AEC-Q200 equivalent standards, their miniature size makes them ideal solutions for space-constrained electronic circuits, and helps to improve reliability of temperature control and aids in increasing safety and efficiency with precise temperature protection benefits.

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 885 877
Email eurocus@bourns.com

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com