THE ADVANTAGES OF MORE ELEGANT CIRCUIT DESIGN IN BATTERY PACKS

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Modern battery packs are often designed with two competing needs in mind. On the one hand, the primary purpose of batteries is to localize power needs. By definition battery-supplied power units are untethered from immobile power sources.

On the other hand, battery packs contain potentially volatile materials that require circuits to be designed with safety mechanisms that can be burdensome in terms of space, reliability, cost and power draw.

This paper will take a look at circuit design and how it can be made more elegant by eliminating unnecessary components and costs

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Table of Contents

At a time when lithium-ion chemistry is becoming the dominant material in new batteries powering everything from electric vehicles (EVs) to remote work tools, safety and battery life have become dominant topics of concern. Yet, many battery management systems still use bulky, expensive, power-depleting sensing systems as integral parts of their BMS. There has to be a better way.

It turns out that a simpler solution is already close-at-hand. Bimetal thermal controls can provide reliable alternatives. They are designed to sense dangerous temperature build-ups and quickly take action to break the circuit, at least until things cool down. The ability of these devices to both sense and take action means design engineers can use them to create more elegant battery circuits. This white paper will show you how.

The State of Battery Circuits

Today, lithium-ion is rapidly becoming the standard for batteries and battery packs, alike. These materials have ascended due to their ability to store significant amounts of energy relative to their size, charge faster and hold charge for longer periods of time. They offer high voltage, excellent charge efficiency and discharge power. They are also far more volatile than nickel-hydride materials, prone to thermal runaway and sensitive to operating temperatures. For these reasons, complex Battery Management Systems (BMS) are required for almost all lithium-based materials used in batteries and battery packs. These management systems add a layer of complexity to circuit design.

In a fast-moving industry it is hard to think of "traditional" circuit design, but the most-often used designs incorporate thermistors wired to some type of controlling device. Thermistors do an excellent job of sensing temperature rise and quickly sending a signal to the BMS, however they do not have the ability to effect the opening or closing of the circuit. A controller is, therefore, required to translate the signal from the thermistors into switching action at the BMS, opening or closing the circuit.

In larger or multiple battery configurations, these controllers require some manner of mounting to an adjacent panel or structural component. Although thermistors, themselves, are cheap, the required infrastructure significantly multiplies their true cost.

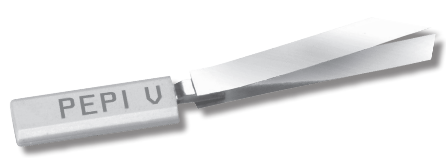
Some battery designs also incorporate thermistors mounted into some type of probe housing. The probe, itself, significantly adds cost and still requires some type of controlling device to translate signal to action.

As a result, thermistor-protected circuits are a jumble of wires leading from each thermistor to the controller and then from the controller to the BMS control panel. As an added complexity, the wire from the thermistor provides the sensing mechanism, so different wires must be used to meet different temperature calibration needs. If a different lithium compound is used, the wires will also change putting a strain on inventory requirements. The end result can be complex, expensive and space-consuming.

While thermistors require significant infrastructure, they also do not provide any short circuit protection leaving batteries exposed to significant ignition danger while also compromising the potential efficiency of the Battery Management System (BMS).

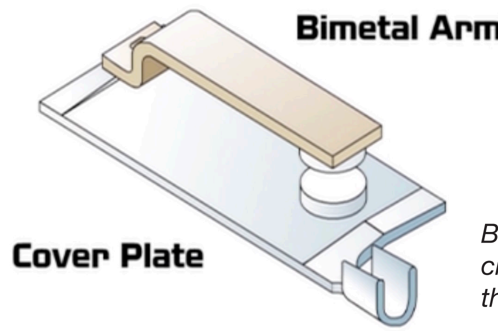
A More Elegant Design Solution

A common device currently used as primary and back-up circuit protection on many applications may provide a more elegant answer in many battery applications. Bimetallic thermal controls immediately turn temperature changes into mechanical action. On temperature rise or fall, a bimetal wing within the device warps upward or down to make or break the circuit. The need for expensive controllers is eliminated and BMS circuit boards, though still required with lithium-ion chemistry, can also be simplified.



The PEPI® Model V has a plastic case specially designed to fit between AA battery cells in battery packs. Low internal resistance means less power draw from the thermal control

Bimetallic thermal controls are essentially self-contained circuit protection systems. Since units are calibrated by dimpling the control case, there is less pressure on the circuit wires. Wires with wider temperature ranges can be used eliminating significant inventory requirements.



Bimetal thermal controls sense temperature change and break or make the circuit without the need for additional control devices

Customization Builds Reliability

An often overlooked benefit of bimetallic thermal controls is the potential to customize them to better meet application requirements. As a battery design is developed, the bimetallic elements can be selected from hundreds of potential solutions to meet the precise sensitivity and reaction speeds necessary to improve the safety performance and minimize power drain.

PEPI® thermal controls can be customized in a number of ways, including different wires and a variety of encapsulations to separate them from ambient concerns.

Circuit wires can be attached and temperature calibrations made at the factory to help cut battery manufacturer's production costs. Individual thermal controls can also be pre-wired into harness configurations when needed for cell-level or module-level protection.

In certain applications where ambient temperatures can affect temperature sensing, bimetallic controls can be encased in sleeves or bubbles to isolate them from those temperatures.

Types of Bimetallic Thermal Controls Used in Battery Applications

There are a wide variety of bimetallic thermal control designs available for different application needs. Proper selection depends on what you need the thermal control to do. For example:

Maintaining operating temperatures within a defined range
Creep Action thermal controls can be used to monitor circuit temperatures and open and close the circuit within a narrow temperature range to maintain ideal temperatures.

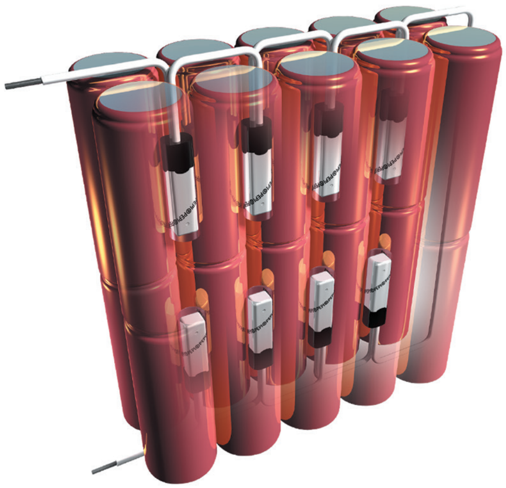
Preventing thermal runaway while maintaining product operation
Snap Action thermal controls will open the circuit upon temperature rise ensuring the battery never overheats. When temperatures fall, the control resets allowing electricity to continue its flow. The distance between opening and closing temperatures can be as wide as necessary.

Ensuring safety by shutting down operation
Thermal Fuses are inexpensive and non-resettable. Once the circuit reaches a pre-set temperature, the fuse breaks the circuit and cannot be reset.

Portage Electric Products, Inc. (PEPI®) is the only thermal control manufacturer to make all three thermal control types available from a single source of supply.

Where Bimetallic Thermal Controls Fit

These type of thermal controls can be integrated into battery and battery pack designs at various levels:



Space is always at a premium inside battery packs

Cell-Level Protection: Thermal protectors mounted directly on or adjacent to individual cells to detect localized overheating.

Module-Level Protection: Used at the module interface to disconnect power or signal a BMS in the event of abnormal thermal rise.

System-Level Redundancy: Hardware thermal switches can serve as a backup to digital Battery Management Systems (BMS), providing an independent cutoff path.

Application Scenarios

As the applications for modern batteries and battery packs have grown, bimetallic thermal controls have kept pace. Today you find these self-contained BMS systems in every type of battery-powered application.

Electric Vehicles (EVs): Cell-level thermal protection within modules to prevent propagation of thermal events.

Portable Power Packs: Resettable thermal switches as compact, low-cost safety devices.

Stationary Energy Storage: Module-level protection layered with BMS for improved fault tolerance.

Consumer Electronics: Miniaturized thermal protectors ensure device safety while maintaining compact form factors.

Conclusion

In a world where cost and performance are too often at war with each other, bimetallic thermal controls give battery designers the ability to do both. Their ability to both sense temperature rise and effectuate the mechanical solution replaces costly BMS solutions using thermistors in combination with the complex wiring and controllers. As a result bimetallic thermal controls offer a versatile and dependable solution to the thermal management challenges in battery systems.

Since they do not operate primarily on circuit resistance, these type of thermal controls also draw less power, helping to extend battery life and meet compliance with international safety standards.

As battery applications continue to grow in complexity and demand, incorporating PEPI® thermal controls ensure cost competitiveness, system integrity and user safety.

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