National Aeronautics and Space Administration

technology opportunity

Power Generation and Storage Portfolio:
Commercialization of Battery Technologies

Battery Management System has the ability to monitor and balance the charge of individual battery cells that are in series and provide fault detection of individual cells in parallel within a battery pack of hundreds of cells.
https://technology.jsc.nasa.gov/patents search: MSC-TOPS-40
YouTube Video search: Battery Management System NASA

Battery Charger Equalizer System provides individual cell charging in multi-cell battery strings using a minimum number of transformers. By effectively keeping all the cells in a multi-cell string at the same charge state, this technology maximizes the battery's life and performance.
https://technology.jsc.nasa.gov/patents search: MSC-TOPS-35

Internal Short Circuit Testing Device to Improve Battery Designs introduces latent flaws into the test batteries to produce an internal short circuit. This device can help battery manufacturers and testers determine which battery designs will best minimize the spread of a thermal runaway-induced fire in the battery or bank of batteries.
https://technology.jsc.nasa.gov/patents search: MSC-TOPS-75
YouTube Video search: Internal Short Circuit NASA

Li-ion Cell Calorimeter is able to measure the total and fractional heat generated when specific types of lithium cells are driven into a thermal runaway condition. Scalable, portable, and reusable this technology is a major improvement from other calorimeters on the market.
https://technology.jsc.nasa.gov/patents search: MSC-TOPS-77

All of these technologies are available for licensing!

For more information:
https://technology.jsc.nasa.gov/patents

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National Aeronautics and Space Administration

Power Generation and Storage

Battery Charge Equalizer System

Extending battery life and performance in large battery arrays

A battery charge equalizer developed at NASA's Johnson Space Center provides individual cell charging in multi-cell battery strings using a minimum number of transformers. By effectively keeping all the cells in a multi-cell string at the same charge state, this technology maximizes the battery's life and performance. Designed to augment a simple high-current charger that supplies overall battery system energy, the innovation achieves equalization without wasting energy or creating excess heat. NASA's battery charge equalizer complements existing high voltage chargers and instrumentation systems and offers safe and low-cost management for lithium-ion (Li-ion) batteries used in electric vehicles and other next-generation renewable energy applications.

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BENEFITS

- Advanced equalization - charges specific individual cells
- Safe - features a fail-safe operation and built-in electrical isolation
- Fast - charges only the cells that need charging, reducing charge time
- Highly efficient - wastes no energy from discharging cells
- Extended battery life - maintains and manages battery charge state

technology solution

THE TECHNOLOGY

The innovation consists of a transformer array connected to a battery array through rectification and filtering circuits. The transformer array is connected to a drive circuit and a timing and control circuit, which enables individual battery cells or cell banks to be charged. The timing and control circuit connects to a charge controller that uses battery instrumentation to determine which battery bank to charge. The system is ultra lightweight because it uses much fewer than one transformer per battery cell. For instance, 40 battery cells can be balanced with an array of just five transformers. The innovation can charge an individual cell bank at the same time while the main battery charger is charging the high-voltage battery system.

Conventional equalization techniques require complex and costly electrical circuitry to achieve cell monitoring and balancing. Further, such techniques waste the energy from the most charged cells through a dummy resistive load (regulator), which is inefficient and generates excess heat. In contrast, this system equalizes battery strings by selectively charging cells that need it. The technology maintains battery state-of-charge to improve battery life and performance. In addition, the technology provides a fail-safe operation and a novel built-in electrical isolation for the main charge circuit, further improving the safety of high-voltage Li-ion batteries.

The NASA developed technology has applications in both electric automotive equipment and grid energy storage.

APPLICATIONS

The technology has several potential applications:

- Electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs)
- Stationary power systems
- Space mission critical battery systems
- Grid energy storage
- Uninterruptible power supply (UPS) systems
- Electric utility storage for renewable energy systems

PUBLICATIONS

Patent No: 8,896,315

More Information

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MSC-25026-1
MSC-TOPS-35

National Aeronautics and Space Administration

Power Generation and Storage

Internal Short Circuit Testing Device to Improve Battery Designs

Introduces various types of internal short circuits that trigger thermal runaway in test batteries

Batteries, such as lithium-ion for example that are sold for consumer use in portable electronic devices and other applications such as electrical cars, occasionally fail in the field over time. These cells have typically passed a wide variety of safety tests, such as those required by governmental shipping regulations and other certification organizations. Nevertheless, they sometimes fail by overheating, which triggers thermal runaway in the battery. This action may engulf the entire device such as a cellular phone or tablet-type devices. To better understand these failure modes, innovators at the NASA Johnson Space Center and the DOE National Energy Renewable Laboratory have developed a battery test device, which introduces latent flaws into the test batteries to produce an internal short circuit. This device can help battery manufacturers and testers determine which battery design will best minimize the spread of a thermal runaway-induced fire in the battery or bank of batteries.

BENEFITS

- Enhanced Energy Storage Safety: Develop new designs to pack and store each cell
- Customizable: Introduces multiple types of internal short circuits
- Adaptable: Easily integrated into test units

APPLICATIONS

- Energy Storage
- Battery Safety
- Electric Vehicles

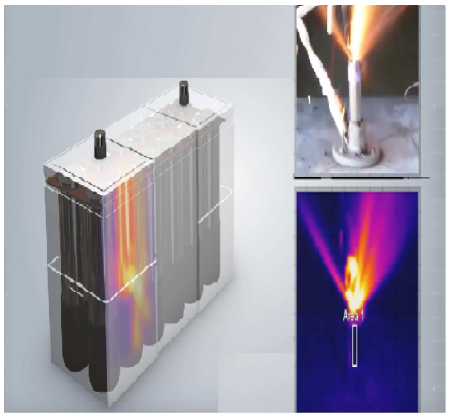
technology solution

THE TECHNOLOGY

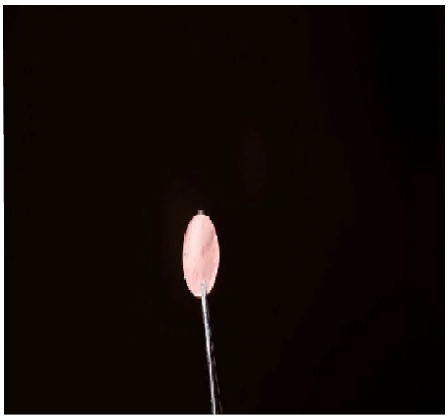
Astronauts' lives depend on the safe performance and reliability of lithium-ion (Li-ion) batteries when they are working and living on the International Space Station. These batteries are used to power everything such as communications systems, laptop computers, and breathing devices. Their reliance on safe use of Li-ion batteries led to the research and development of a new device that can more precisely trigger internal short circuits, predict reactions, and establish safeguards through the design of the battery cells and packs. Commercial applications for this device exist as well, as millions of cell phones, laptops, and electronic drive vehicles use Li-ion batteries every day. In helping manufacturers understand why and how Li-ion batteries overheat, this technology improves testing and quality control processes.

The uniqueness of this device can be attributed to its simplicity. In a particular embodiment, it is comprised of a small copper and aluminum disc, a copper puck, polyethylene or polypropylene separator, and a layer of wax as thin as the diameter of one human hair. After implantation of the device in a cell, an internal short circuit is induced by exposing the cell to higher temperatures and melting the wax, which is then wicked away by the separator, cathode, and anode, leaving the remaining metal components to come into contact and induce an internal short. Sensors record the cell's reactions. Testing the battery response to the induced internal short provides a 100% reliable testing method to safely test battery containment designs for thermal runaway.

This jointly developed and patented technology is available for your company to license and develop into a commercial product. NASA does not manufacture products for commercial sale.



Battery is being tested by inducing the Internal Short Circuit method to one of the cells while introducing heat.



Dime-sized coin made of aluminum and copper is used to induced shot circuits in lithium-ion batteries.

PUBLICATIONS

Patent No: 9142829

More Information

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MSC-26169-1
MSC-TOPS-75

National Aeronautics and
Space Administration

Power Generation and Storage

Li-ion Cell Calorimeter

Cell Thermal Runaway Calorimeter

Innovators at the NASA Johnson Space Center have developed a calorimeter that is able to measure the total heat generated when specific types of Lithium-ion (Li-ion) cells are driven into a thermal runaway condition. By understanding the behavior of a thermal runaway Li-ion battery, designers can improve the cell cases to contain or reduce damages experienced during thermal runaway. For this reason, this technology can benefit many different industries that depend on Li-ion batteries.

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BENEFITS

- Reusable: Designed for multiple tests within minutes
- Scalable: Adjusts to different-sized cells
- Inexpensive: Uses materials that are readily available
- Portable: Fits in a carrying case for testing and transporting

technology solution

THE TECHNOLOGY

Li-ion batteries are an integral part of energy storage systems used in NASA's Exploration program, as well as many modern terrestrial industries. Innovators at the NASA Johnson Space Center wanted a better way to measure total and fractional heat response of specific types of Li-ion cells when driven into a thermal runaway condition. They developed a calorimeter with at least two chambers, one for the battery cell under test and at least one other chamber for receiving the thermal runaway ejecta debris. Both are designed to be structurally strong and thermally insulated. When the test cell is intentionally driven into thermal runaway, ejecta explodes into the ejecta chamber and is decelerated and collected. Thermal sensors are strategically placed throughout the chambers to collect thermal data during the test. Customized software analyzes the thermal data and determines key calorimeter parameters with a high degree of accuracy.

This technology makes commercial lithium batteries safer and more reliable.

APPLICATIONS

The technology has several potential applications:

- Consumer Electronics
- Energy Storage
- Battery Safety
- Electric Vehicles
- Electric Bikes
- Cordless Tools
- Lawn Equipment

PUBLICATIONS

Patent Pending

More Information

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MSC-26303-1
MSC-TOPS-77

National Aeronautics and Space Administration

Power Generation and Storage

Battery Management System

Simple, reliable, and safe battery management for high-voltage battery systems

NASA seeks interested parties to license the Battery Management System (BMS) developed by innovators at Johnson Space Center. NASA's BMS features the ability to monitor and balance the charge of individual battery cells that are in series and provide fault detection of individual cells in parallel within a battery pack of hundreds of cells. The circuit uses fewer connections (pins) than competing technologies, which reduces complexity and improves reliability. It offers a safe and potentially low-cost management system for high-voltage battery systems, including lithium-ion (Li-ion) battery systems that are used in electric vehicles and other next-generation renewable energy applications.

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BENEFITS

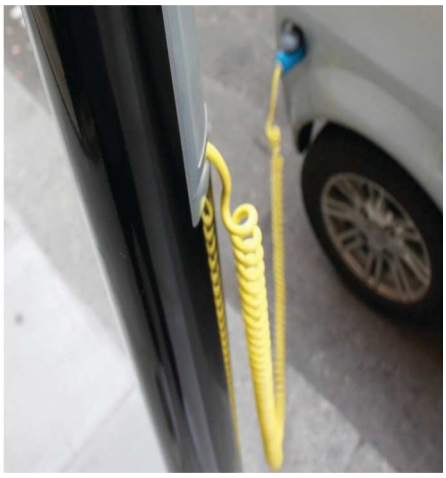
- Safety: decreases the occurrence of thermal runaway and catastrophic failures
- Reliability: uses a low pin count; reduced complexity and increased reliability
- Dual-purpose - detects the individual bad cells within series and parallel cells
- Extended battery life: manages battery cells within a string increasing battery life
- Decreased battery damage: prevents damage from too much or too little voltage
- Limited charge current - balances cells by adding charge to individual cells after main charge is complete
- Low cost - provides a less expensive alternative to existing, commercially available solutions

technology solution

THE TECHNOLOGY

The technology is comprised of a simple and reliable circuit that detects a single bad cell within a battery pack of hundreds of cells and it can monitor and balance the charge of individual cells in series. NASA's BMS is cost effective and can enhance safety and extend the life of critical battery systems, including high-voltage Li-ion batteries that are used in electric vehicles and other next-generation renewable energy applications.

The BMS uses saturating transformers in a matrix arrangement to monitor cell voltage and balance the charge of individual battery cells that are in series within a battery string. The system includes a monitoring array and a voltage sensing and balancing system that integrates simply and efficiently with the battery cell array, limiting the number of pins and the complexity of circuitry in the battery. The arrangement has inherent galvanic isolation, low cell leakage currents, and allows a single bad or imbalanced cell in a series of several hundred to be identified. Cell balancing in multi-cell battery strings compensates for weaker cells by equalizing the charge on all the cells in the chain, thus extending battery life. Voltage sensing helps avoid damage from over-voltage that can occur during charging and from under-voltage that can occur through excessive discharging.



The NASA developed technology could be applicable in electric vehicle battery charging station technologies.

APPLICATIONS

The technology has several potential applications:

- Electric vehicles (EVs), plug-in hybrid (PHEV), and hybrid electric vehicles (HEVs)
- Telecommunications backup systems
- Space mission critical battery backup systems
- Uninterruptible power systems
- Electric utility storage for renewable energy
- High-voltage critical battery systems

PUBLICATIONS

Patent No: 8183870; 8570047

More Information

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MSC-24466-1, MSC-24509-1
MSC-TOPS-40