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# Lithium Battery Pack Protection and Control

Appliances

Energy Storage

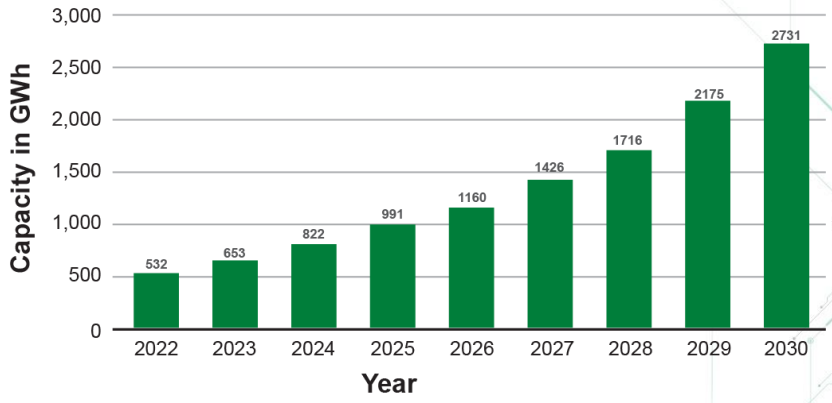


REV1123

# Lithium batteries market statistics and drivers

| Market trends and drivers |
| --- |
| Safety and ageing concerns in Lithium battery applications highlight the critical need for advanced protection and control solutions in the market. |
| Adoption of electric vehicles, both in the automotive and e-mobility sectors, is driving the demand for high-performance lithium battery solutions. |
| Lithium batteries are widely used in energy storage applications, from residential to grid-scale systems. With the growing emphasis on renewable energy sources and the need for reliable energy storage. |
| Increasing environmental regulations and a growing focus on sustainability are pushing manufacturers to develop more energy-efficient and eco-friendly battery solutions. |

**Estimated capacity of Lithium batteries growing at a ~28% CAGR (in gigawatt hours)**




*Source:* Statista

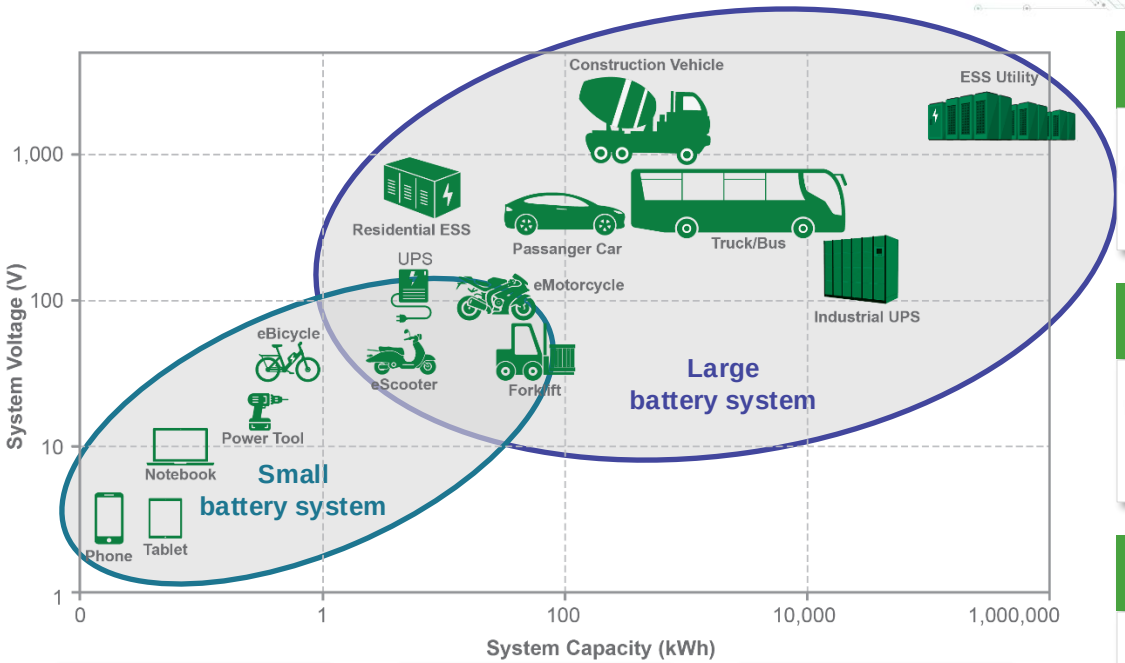
# Littelfuse offers solutions for every battery system

*Smart phones ➔ large eMobility batteries ➔ utility-grade systems*

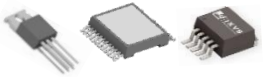
**Overcurrent Protection**
Fuse, PPTC, Battery Protector, Battery Mini-breaker

**Overvoltage Protection**
MOV, SPD, SIDACtor®, TVS Diode

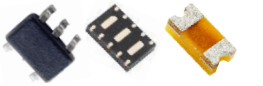
**Sense Line Protection**
Fuse, TVS Diode




**Power Control**
MOSFET/IGBT, Power Module, Gate Driver



**ESD Protection**
TVS Diode, TVS Diode Array, Polymer ESD



**Sensing Solution**
Magnetic Sensor, Temperature Sensor, TTape™

** Contact sales for details*

**Isolation Monitoring**
Solid State Relay, Reed Relay

**Battery Disconnect**
DC Disconnect Switch, HVDC Contactor Relay

**Ground Fault and Arc-flash protection**
Ground Fault Relay, Arc-flash Relay

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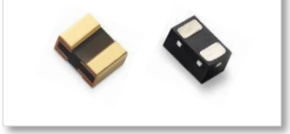
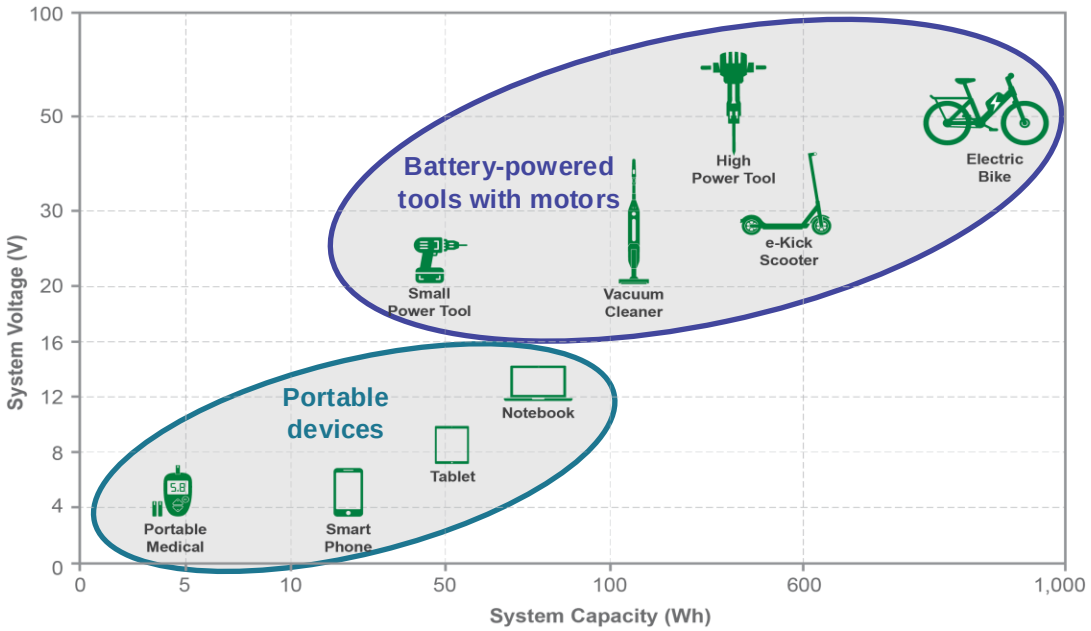
# Small battery system application map

**Cell-level Protection**
PPTC, Battery Strap, Battery Mini-breaker

**Secondary Protection (Battery-pack Level)**
Fuse, Battery Protector, TVS Diode

**Signal Line Protection**
PPTC, TVS Diode Array






**USB Port Protection**
eFuse, Temperature Indicator, PPTC, TVS Diode Array

**Temperature Sensing**
NTC, RTD, TTape™

**Battery Status Indicator**
Tactile Switch

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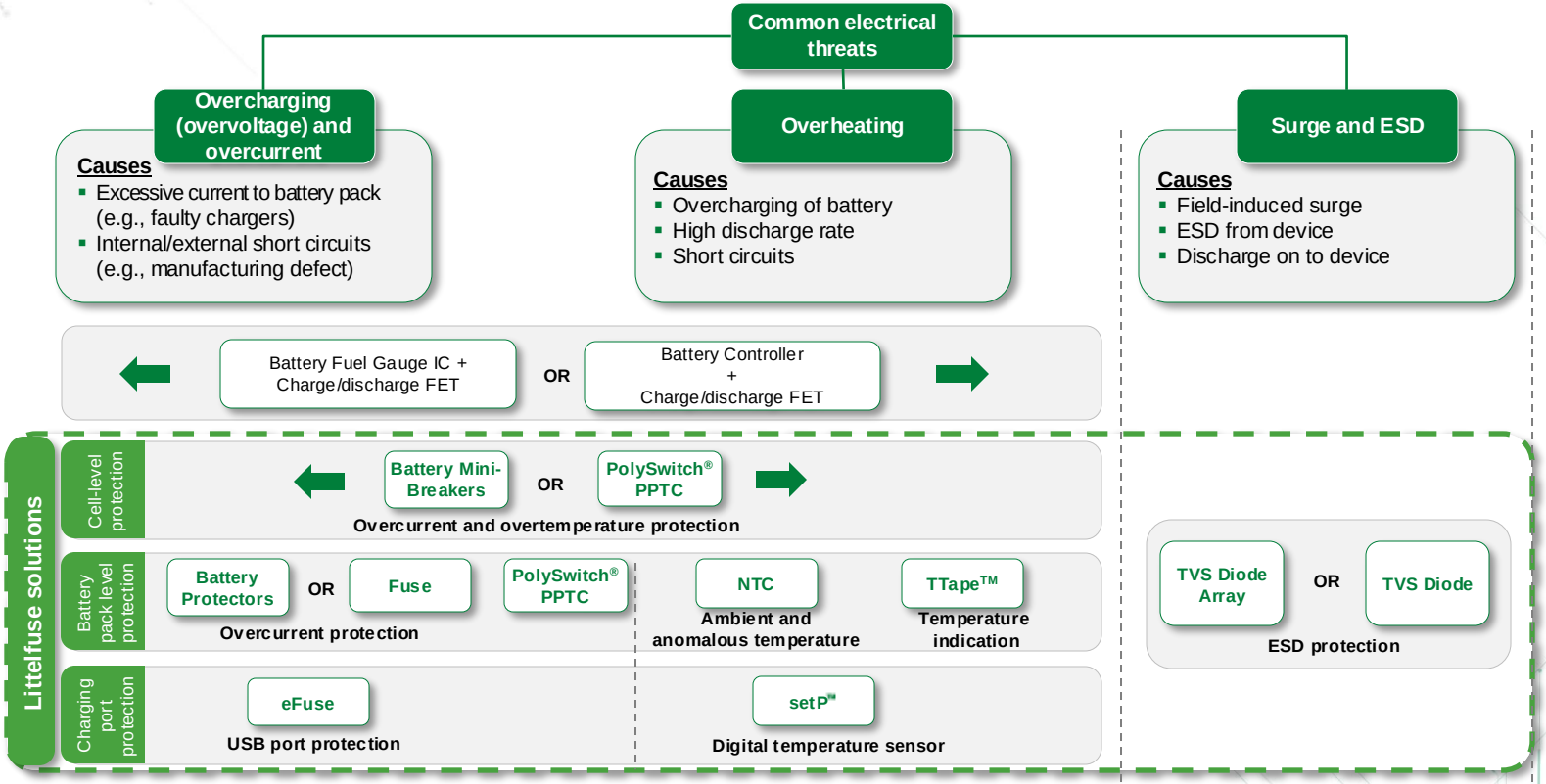
# Common hazards related to Lithium battery systems

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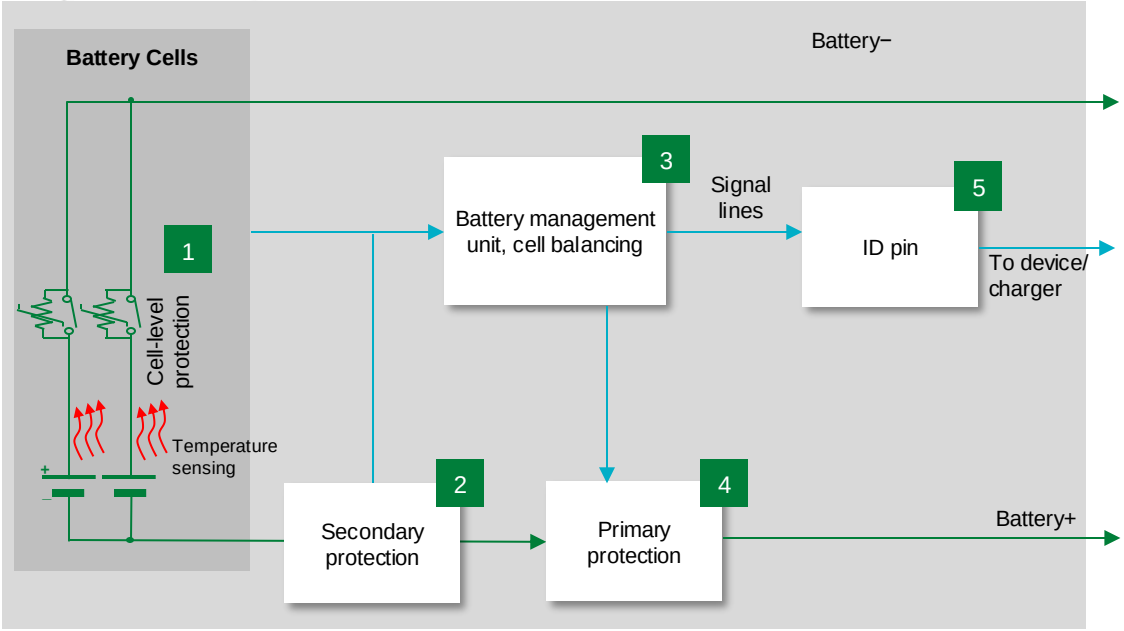
Click the product series in the table below for more info

# Battery pack system architecture: small up to 60 V




| | Technology | Product series |
|---|---|---|
| 1 | NTC | KC |
| | TTape™ | TTP |
| | PPTC *OR* MHP | LSP *OR* MHP-TAT18 |
| 2 | Fuse *OR* Battery Protector | 881, 688 *OR* ITV |
| 3 | Fuse *OR* PPTC | 458 *OR* 0805L |
| | Current Sensing Resistor | L4CL |
| 4 | TVS Diode | SMF, SMF4L |
| 5 | TVS Diode Array | SP1006 |
| | PPTC | zeptoSMDC |

*Legend:*
- *Power*
- *Data*

- ***Secondary protection:*** *Protects cells if the primary safety circuit fails.*
- ***Primary protection:*** *Handles all the basic safety functions: overvoltage, undervoltage, overcurrent, under-temperature, and overtemperature.*

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Click the product series in the table below for more info

# Features and benefits of Littelfuse products

| | Technology | Function in application | Product series | Benefits | Features |
|---|---|---|---|---|---|
| 1 | NTC | Analog temperature monitoring to facilitate functional control of batteries | KC | Provides accurate temperature readings to enable safe device operation | Insulated lead wires; small form factor; fast thermal response |
| | TTape™ | Managing battery lifetime and helping identify hazardous temperature levels | TTP | Simple integration with existing BMS architectures + enables enhanced BMS control systems | Trip temperature of 58±3 °C, up to 50 sensing points on one string; enable BMS wakeup and single GPIO port usage |
| | PPTC ***OR*** MHP | Cell-level protection; overtemperature and overcurrent protection at the cell level | LSP ***OR*** MHP-TAT18 | Low resistance to maximize battery life; suitable for automotive applications (AEC-Q200 qualified) | Compact, space-saving size; holds a current of up to 5.5 A; RoHs-compliant |
| | | | | Allows ultra-thin battery pack designs; enhances battery safety in mobile devices; provides resettable protection, ensuring device longevity | 9 VDC rating and high current capacity; multiple activation temperatures; UL-, CSA-, and IEC-evaluated |
| 2 | Fuse ***OR*** Battery Protector | Non-resettable overcurrent protection | 881, 688 ***OR*** ITV | Reduces customer qualification time in compliance with third-party safety standards such as UL/IEC | Third-party compliance with UL/IEC, low internal resistance; shock-safe; vibration-resistant |
| | | Non-resettable overcurrent and overcharge protection (activated on demand) | | Offers overcurrent and overcharge protection and controlled disconnection; can be activated by BMS | Surface-mountable; UL- and TUV-certified; three-pin device; controlled fusible element |
| 3 | Fuse ***OR*** PPTC | Non-resettable (Fuse) or resettable (PPTC) protection for Battery Management System MOSFET from high currents due to external shorts | 458 ***OR*** 0805L | Saves space with a smaller footprint | Surface-mountable; UL- and TUV-certified; three-pin device; controlled fusible element |
| | | | | Reduces customer qualification time in compliance with third-party safety standards such as UL/IEC; allows compact design with SMD form factor | Surface-mountable; compatible with lead-free solder processes as per IEC standards; PPTC only for single-cell applications |
| | Current Sensing Resistor | Part of current measurement circuitry | L4CL | Cost-effective solution compared to competing technologies; compact size; late temperature de-rating | Tolerance down to 0.5%; separate voltage-sensing terminals; SMD form factor |
| 4 | TVS Diode | Protects battery packs from overvoltage conditions due to abnormal charging conditions | SMF, SMF4L | Improves system reliability by protecting downstream components from transients on power lines | Low profile with a maximum height of 1 mm; low leakage of 1.0 µA |
| 5 | PPTC | Overcurrent protection for TVS or Zener diodes | zeptoSMDC | Resets to normal operation after fault is cleared; saves space with a smaller footprint | Maximum electrical rating: 13 VDC; short circuit current: 82–200 mA; small footprint 0201 size |
| | TVS Diode Array | ESD protection of $I^2C$ or other MCU/BMS ports | SP1006 | Small, space-saving design prevents signal disruption with low capacitance | µDFN-2 (0201) footprint; ±30 kV ESD withstand voltage |

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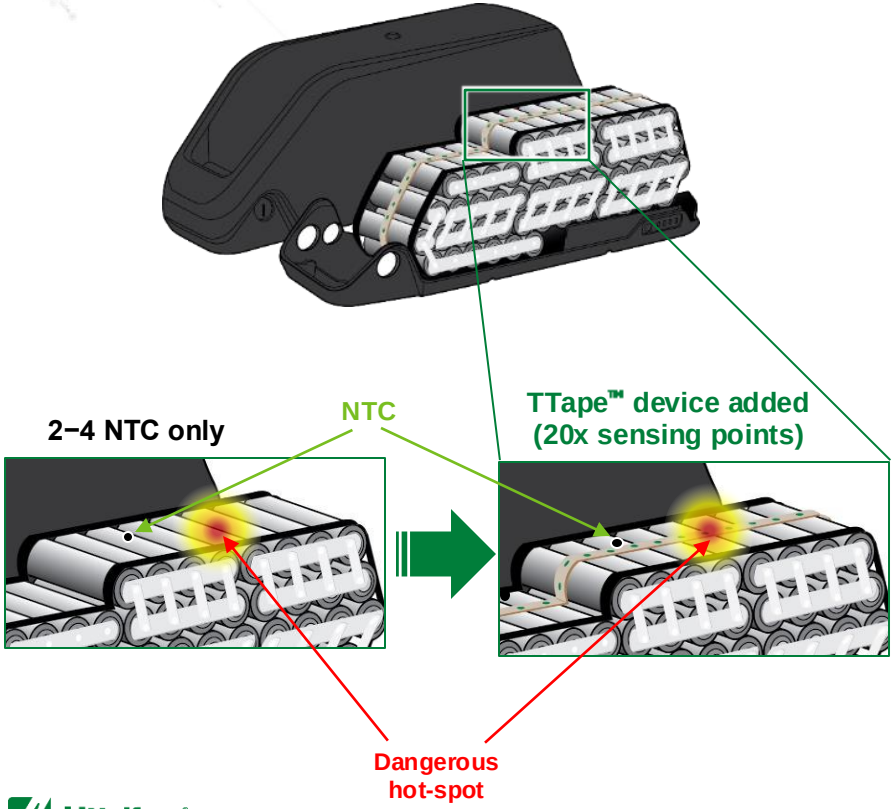
# Digital temperature monitoring for battery systems (TTape™)

# TTape™ platform: overtemperature detection at each cell




- **Detect** dangerous hotspot due to cell imbalance, ageing, external heat, high load or fast charging
- Extends serviceable **life** of battery packs and adds **safety**:
  - **Increase resolution** of temperature monitoring areas, TTape™ platform sensing points are on each cell
  - Monitors many cells/large areas using a **single** TTape device, thus saving processing power
  - **Ultra-fast responses for quicker alerts**
- Can **wake** BMS in-case of overtemperature
- **No calibration** + **simple** integration with BMS
- ≤ 500 µm thin → **conformal installation**

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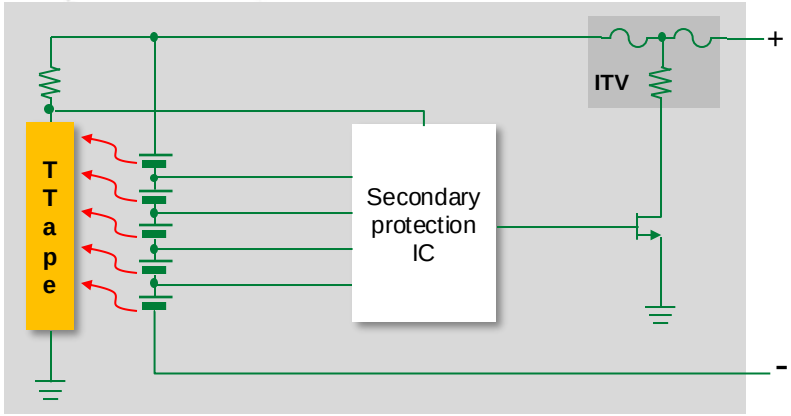
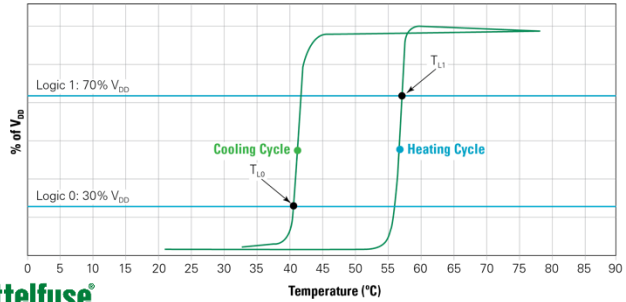
# TTape™ platform and ITV: monitoring for rechargeable Lithium batteries




** ITV – Three-terminal fuse. Third heater terminal activated by MOSFET.*

**Temperature Indication Characteristics**




*$V_{DD}$– Voltage supply to the drain*

- TTape™ device detects the temperature of each battery cell and connects to battery protection IC
- When a cell's temperature exceeds limits, TTape™ resistance change is recorded by MCU. MCU activate a cutoff mechanism (in this example MOSFET with ITV)
- The MCU could take other action based on the TTape™ alert, such as initiating cooling systems or alerting users to potential safety issues.

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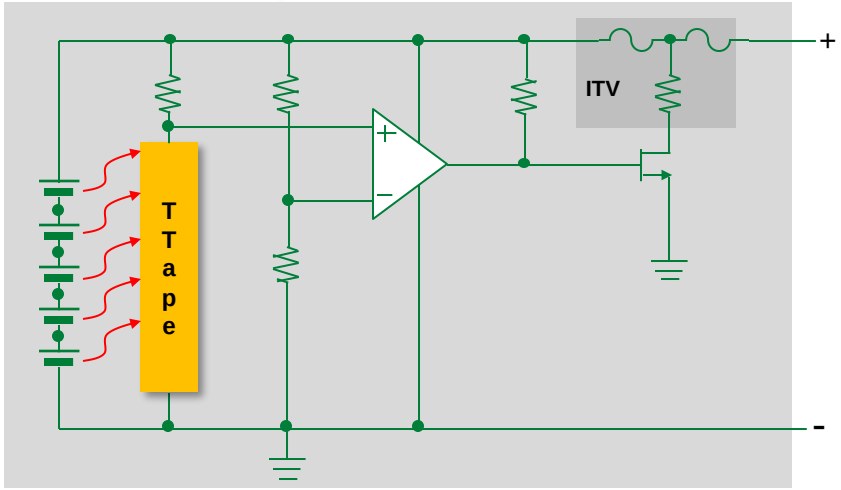
# TTape™ platform and ITV: monitoring for Alkaline and primary Lithium batteries

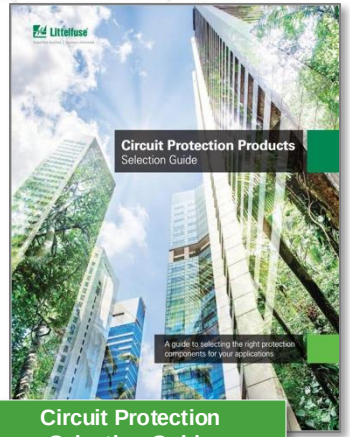



** **ITV** – Three-terminal fuse. Third heater terminal activated by MOSFET.*

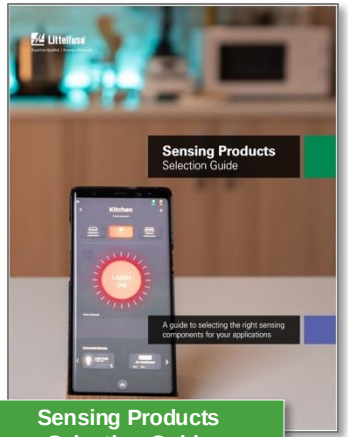
- TTape™ device detects the temperature of each battery cell and connects to comparator.
- The comparator evaluates this resistance change; if it indicates an overtemperature condition, device sends a signal to activate the MOSFET.
- The activated MOSFET then triggers the ITV (Three-terminal Fuse), which disconnect the power to the battery, preventing thermal runaway or potential battery damage.

# Additional information can be found at Littelfuse.com

*Explore the world of Littelfuse products and applications with eCatalogs (ecatalogs.littelfuse.com)*

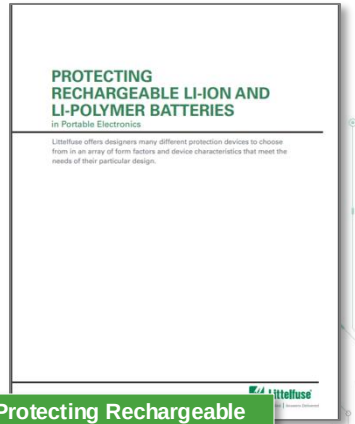



Circuit Protection Selection Guide



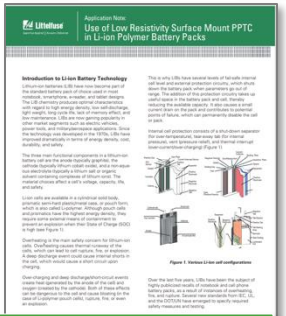

Sensing Products Selection Guide


Circuit Protection Solutions Li-Ion Cell

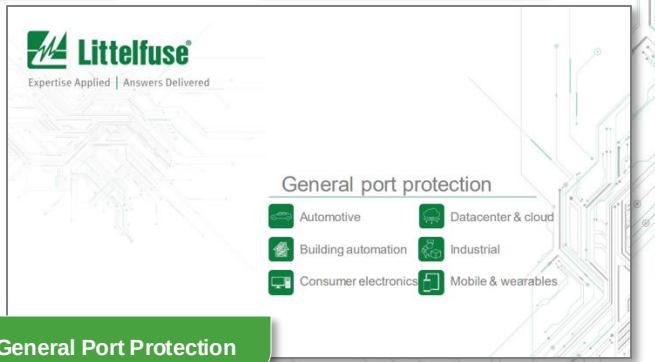



Protecting Rechargeable Li-ion Batteries

Click on the images for more information




Lithium-Ion Battery Pack Protection with PPTC




General Port Protection

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# Local resources supporting our global customers


*Legend*

- *Sales*
- *R&D*
- *Manufacturing*

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Our engineers partner directly with customers to speed up product design and meet their unique needs

**Global customer service**

Our global customer service team is with you and can anticipate your needs to ensure a seamless experience


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