






# Battery Systems in Light Electric Vehicles (>60 V)

- 2/3-Wheeler & Recreational
- Energy Storage

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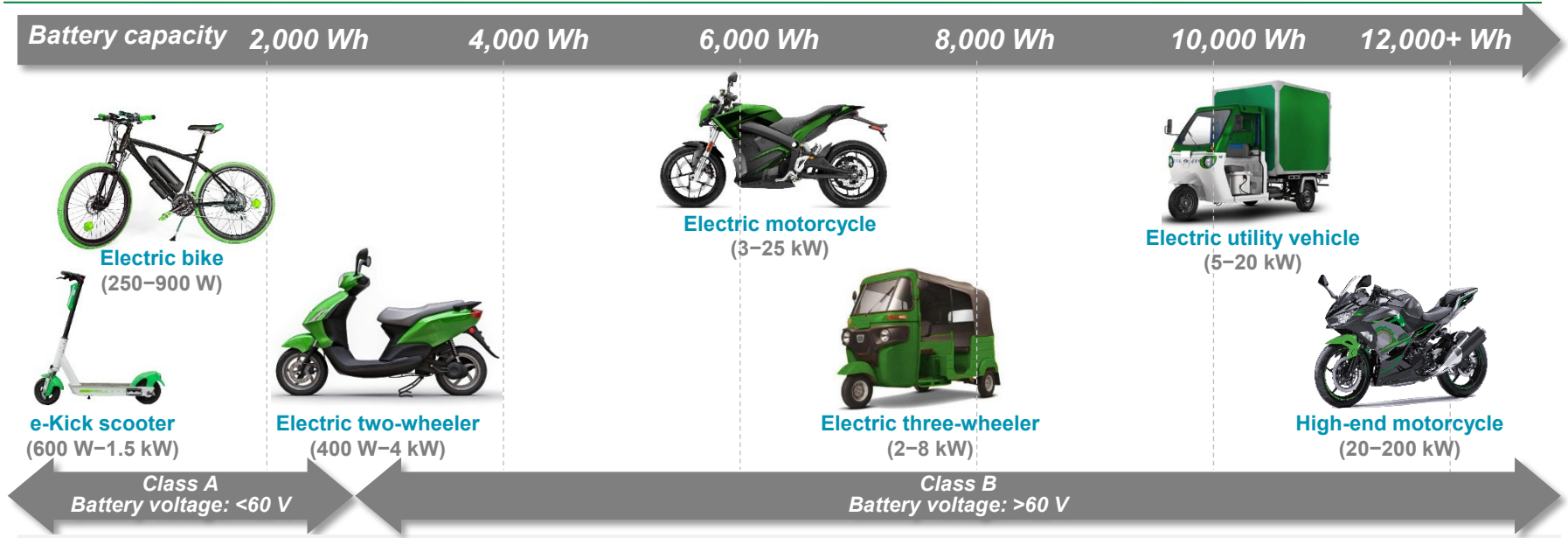
# What are Light Electric Vehicles (LEVs)?


LEVs are compact, battery-powered rides revolutionizing urban travel through clean, efficient, and agile mobility.

# Battery voltage, current, and power ranges by LEV type

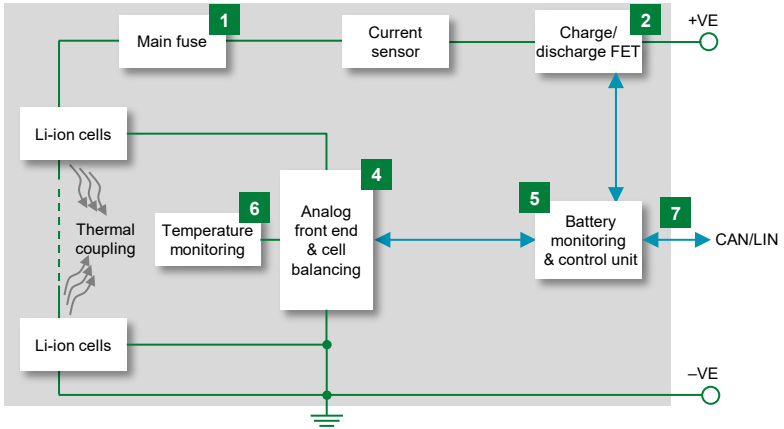



- **Electric bike:** 36–52 V → 48 V standard; 10–25 A → higher torque; used for city travel, by university students, etc.
- **e-Kick scooter:** 36–60 V → 48 V growing; 10–30 A; popular for urban commuting; moving to more power
- **Electric two-wheeler:** 48–72 V → 60 V+ popular; 20–50 A; used for city travel
- **Electric three-wheeler:** 48–96 V → 72 V+ rising; 30–100 A; cargo + passenger transit
- **Electric utility vehicle:** 72–120 V+ → 100 V+ common; 50–150 A; industrial and logistics
- **High-end motorcycle:** 72–120 V+ → 100 V+ high-end; 50–300 A; consumer and sports

# Battery Management System (BMS) architecture: comparing between different LEVs

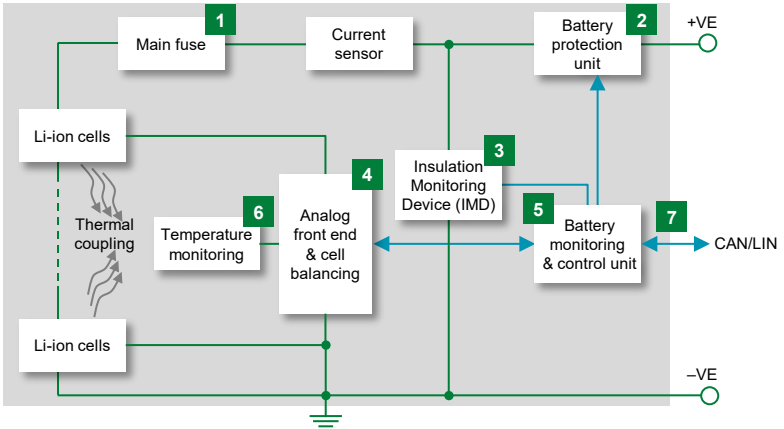
**LEVs <60 V, Class A**

*(e-Bike, e-Kick scooter, Electric two-wheeler)*




**LEVs >60 V, Class B**

*(Electric two-/three-wheeler, High-end motorcycle)*




| | Protection node | Function | <60 V (Class A) | >60 V (Class B) |
|---|---|---|---|---|
| 1 | Main fuse | Clears hard shorts; protects pack, wiring, & controller | **Voltage:** ≤58.8 V; **Icont:** ~20–60 A; **Peaks:** 2–3×; **I_SC:** ~0.4–0.9 kA | **Voltage:** 67–120 V; **Icont:** 80–200 A+; **Peaks:** 2–3×; **I_SC:** ~1–5 kA |
| 2 | Battery protection unit | Connects/disconnects the pack from the vehicle | Usually performed by **MOSFETs** (often many in parallel) | **MOSFETs** rated up to 200 V **+ DC Contactor Relay** rated for DC (up to 300 V) and high currents (up to 250 A) |
| 3 | IMD (isolation monitor) (to HV+, HV−, chassis) | Detects leakage to chassis; prevents contactor from closing; trips during operation | Not generally used | **Solid State Relays** used to switch safely, and reliably switch high-voltage, ultra-low-current measurement paths |
| 4 | Balancing circuit/AFE protection | Isolates a shorted/abused sense lead; protects AFE and harness | **SMD fuse** with high DC rating (commonly 125 VDC) and current rating (typically from 0.25–1 A) | Similar to <60 V |
| 5 | Secondary protection at battery pack level | Permanently opens the pack under unrecoverable faults (especially overvoltage/overcharge) | **Three-terminal fuse** rated up to 80 V and 60 A | SMD or Bolt-Down Three-Terminal Fuse rated up to 125 V and 150 A |
| 6 | Temperature monitoring | Cell temperature sensing | **NTC + TTape™ Platform** | **NTC + TTape™ Platform** |
| 7 | Communication line | I/O port, CAN/LIN protection against ESD | **TVS Diode Array** | **TVS Diode Array** |

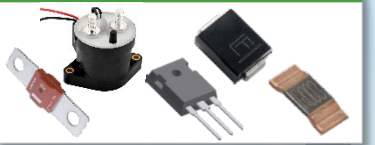
# Battery protection & control solutions for LEVs <60 V

Electric bike, e-kick scooter, pedelec, and low-power electric two-wheeler such as moped and scooter

# Battery protection & control solutions for LEVs >60 V

High-power electric two-/three-wheelers, electric utility vehicles, high-end motorcycles, etc.

**Main fuse + Battery disconnect unit**
Fuse, DC Contactor Relay, MOSFET, TVS Diode, Current Sensing Resistor



**Temperature monitoring**
NTC, TTape™ Platform

**AFE and Cell balancing**
Fuse, PolySwitch® Resettable Device, TVS Diode


**Insulation Monitoring Device (IMD)**
Solid State Relay

**Communication interface**
TVS Diode Array, PolySwitch® Resettable Device

**Battery swap/ Battery detection/Anti-tamper**
Reed Switch, Switch

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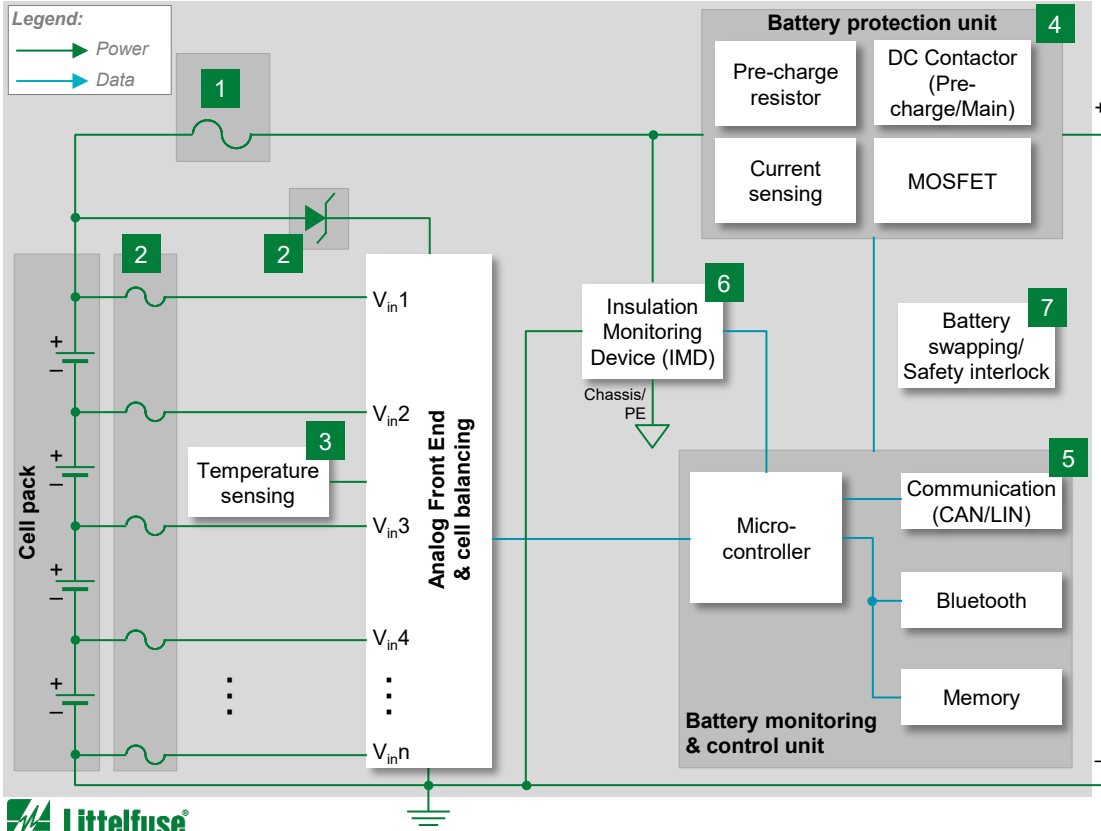
Click the product series in the table below for more info

# Functional block diagram of BMS used in LEVs >60 V




| | Technology | Product series |
|---|---|---|
| 1 | Fuse, Fuseholder | MIDI 70V, Mega, MAXI 58V, 871, 881, LP Jcase, ATO |
| 2 | Fuse **OR** PolySwitch® Resettable Device | 438A, 437A, MINI, 521 |
| | | 1812L |
| | TVS Diode | TPSMB-L |
| 3 | NTC | Leaded, Surface Mount |
| | TTape™ Platform | TTP |
| 4 | DC Contactor Relay | DCNEV, DCNLEV, DCNLR |
| | MOSFET | 200V X4-Class, Trench (T, T2) |
| | TVS Diode | TPSMD, TP5.0SMDJ, SZ5KASMC |
| | Current Sensing Resistor | WSTM-A, SSA |
| 5 | TVS Diode Array | AQ24COM-02, AQ24COM-01 |
| | PolySwitch® Resettable Device | nanoASMD |
| 6 | Solid State Relay | LAA110, LCA701, CPC1009N |
| 7 | Reed Switch | MDSR-10 |
| | C&K® Switches | ZMS, ZMSM, LCS, KSC, ZMV, ZMW, ATS |

Click the product series in the table below for more info

# Benefits of recommended Littelfuse products

| | Technology | Function in application | Product series | Benefits | Features |
|---|---|---|---|---|---|
| 1 | Fuse, Fuseholder | Clears hard shorts; protects pack, wiring, and controller | MIDI 70V, Mega, MAXI 58V, 871, 881, LP Jcase, ATO | Provides safety protection in low- and medium-voltage environments; full-range fuses | Bolt down, bladed, and SMD form factors; high breaking capacity; meets ISO 8820 standard or new AEC-Q specification |
| 2 | Fuse<br>**OR**<br>PolySwitch® Resettable Device | Protect the balancing circuit/the AFE | 438A, 437A, MINI, 521 | Ensures excellent temperature stability and performance reliability; ceramic substrate ensures compatibility with high-temperature environment | Meets new AEC-Q specification; fast response to fault current; surface mount device |
| | | | 1812L | Compact design saves board space; resettable protection | Low profile; fast response to fault currents; low resistance |
| | TVS Diode | Cell monitor IC sense line input overvoltage protection | TPSMB-L | Excellent clamping capability; meets automotive industry standards; fast response time; low reverse leakage current ($I_R$) | AEC-Q101 qualified; meets IEC standards for ESD protection and ISO standards for in-vehicle transient surges |
| 3 | NTC | Monitors analog temperature to facilitate functional control of batteries | Leaded, Surface Mount | Allows for high-precision temperature measurement in harsher environments | UL recognized with ring lug mounting; SMD NTCs in hermetically sealed MELF package suitable for operation up to 220 °C |
| | TTape™ Platform | Manages battery lifetime and helps 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; enables BMS wakeup and single GPIO port usage |
| 4 | DC Contactor Relay | Connects and disconnects battery from main circuitry | DCNEV, DCNLEV, DCNLR | Allows a low-voltage signal to switch the contacts for a high-voltage signal | Wide range of capabilities: can switch up to thousands of amps and thousands of volts |
| | MOSFET | Battery protection (hybrid/solid-state) | 200V X4-Class, Trench (T, T2) | Protects contactor from arcing, smoother pre-charge, lower EMI, programmable protection, enables rapid fault clearance | Low $R_{DS(on)}$, bidirectional current flow, strong SOA, gate-driver control, silent switching |
| | TVS Diode | Protects against voltage spikes and transients | TPSMD, TP5.0SMDJ, SZ5KASMC | Optimize board space; prevents nuisance trips/resets | Excellent clamping capability, high surge capability, low Zener impedance, and fast response time; SMD low profile surface mount package |
| | Current Sensing Resistor | Measures pack charge/discharge current | WSTM-A, SSA | High sensing accuracy; low thermal offset drift; low thermal sensitivity drift | Isolated from HV network; no additional power loss due to shunt resistor |

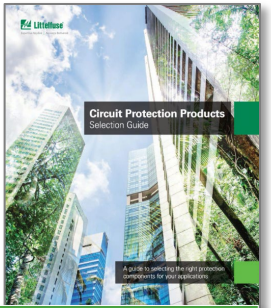
Click the product series in the table below for more info

# Benefits of recommended Littelfuse products

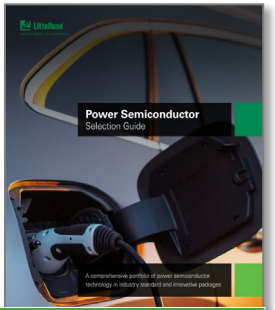
| | Technology | Function in application | Product series | Benefits | Features |
|---|---|---|---|---|---|
| 5 | TVS Diode Array | Protects sensitive electronic ICs from ESD, EFT, and voltage spikes | AQ24COM-02, AQ24COM-01 | Ensures reliable equipment with no degradation in communication line performance | AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2 and ISO 10605; low leakage current and clamping voltage |
| | PolySwitch® Resettable Device | Resettable overcurrent protection | nanoASMD | Reduce weight of wire harnesses; low the use of smaller wire sizes; solid state composition of PPTC devices helps provide reliability | Surface mount; rated up to 60 V; meets automotive industry standards |
| 6 | Solid State Relay | Monitors isolation | LAA110, LCA701, CPC1009N | Allows robust operation in a small four-pin package | 1500 V I/O isolation; low drive requirements; no arching |
| 7 | Reed Switch | Provides the control signal for the battery pack | MDSR-10 | Ensures contamination resistance and a compact design | Switches up to 200 VDC or 0.5 A at up to 10 W; $10^{12}$ Ω insulation resistance |
| | C&K® Switches | Enables battery detection switching | ZMS, ZMSM, LCS, KSC, ZMV, ZMW | Confers long electrical and mechanical life; ideal when space is limited | IP65/IP67; SPST NO/SPST NC/SPDT; compact size |
| | | Anti-tamper protection | ATS | Withstand harsh environments; long life; small footprint | IP54 sealed; vertical detect and a normally closed function |

# Additional information can be found at Littelfuse.com

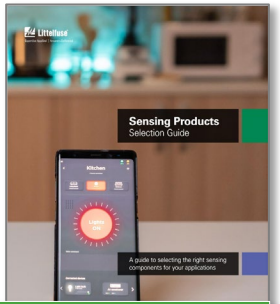
Explore the world of Littelfuse products and applications with ecatalogs (ecatalogs.littelfuse.com)




Circuit Protection Selection Guide




Power Semiconductor Product Catalog




Sensing Products Selection Guide

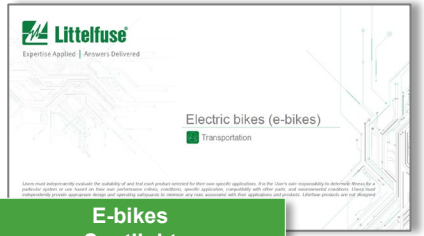

Integrated Circuit Selection Guide


C&K Switches Selection Guide

**Click** the images for more information


Electric Two-/Three-Wheeler Solutions Spotlight


BMS Protection Spotlight



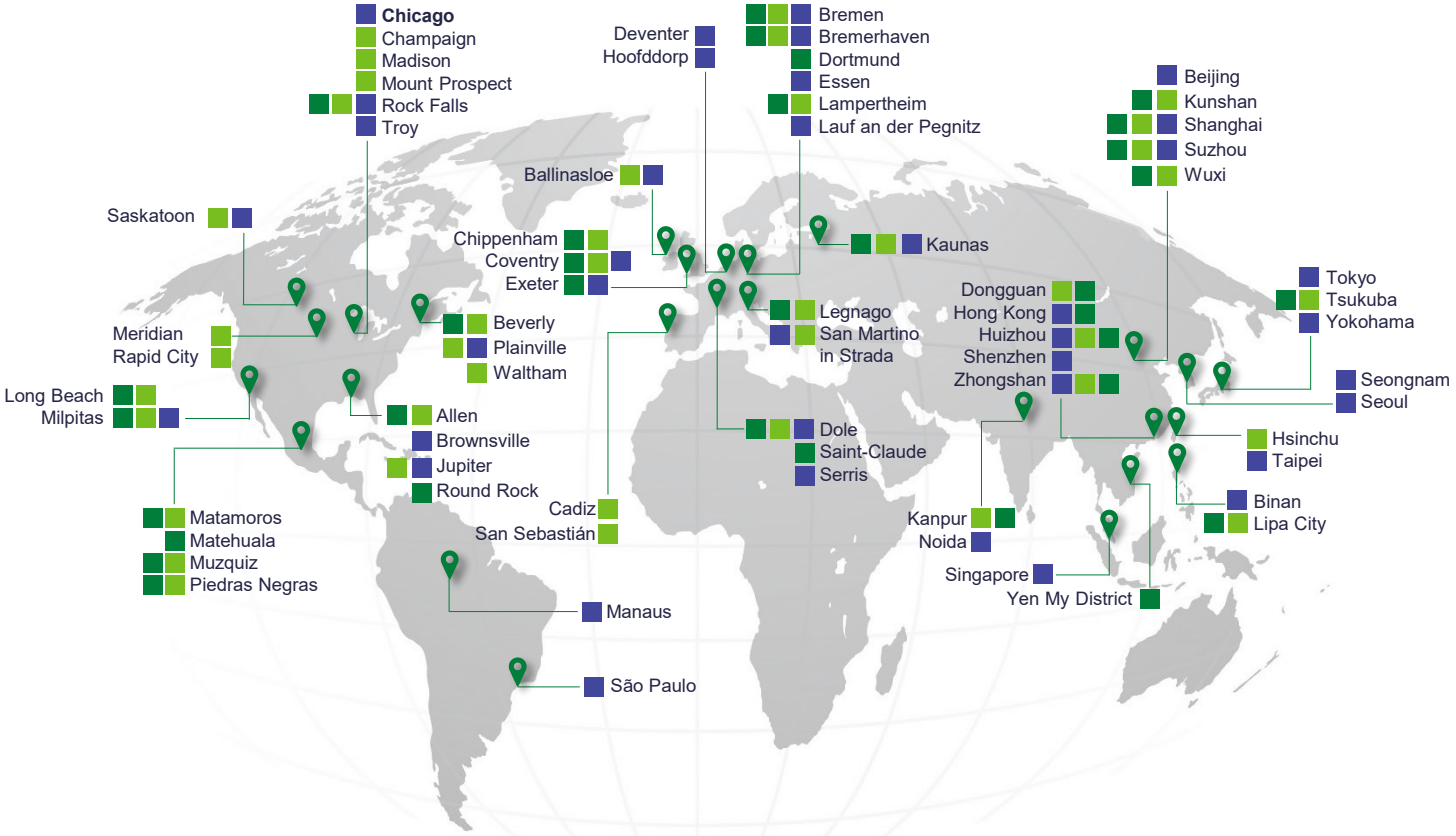

E-bikes Spotlight

Scan the code to learn more!



# Local resources supporting our global customers

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