Users must independently evaluate the suitability of and test each product selected for their own specific applications. It is the User’s sole responsibility to determine fitness for a particular system or use based on their own performance criteria, conditions, specific application, compatibility with other components, and environmental conditions. Users must independently provide appropriate design and operating safeguards to minimize any risks associated with their applications and products. Littelfuse products are not designed for, and may not be used in, all applications. Read complete Disclaimer Notice at: www.littelfuse.com/disclaimer-electronics.
Many battery powered devices, in very different applications, share similar safety and control elements.
Global power tool market statistics & drivers

<table>
<thead>
<tr>
<th>Market Trends and Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The global power tool market is growing at a CAGR of 8.5% between 2019 to 2026 (~200 M-units).</td>
</tr>
<tr>
<td>Cordless power tools experiencing rapid growth representing 50% share of electric power tools shipments.</td>
</tr>
<tr>
<td>The major factor driving the adoption of battery power tools is their portability, which enables the user to operate them without the need for external power supply.</td>
</tr>
<tr>
<td>Demand for longer run-times and lighter systems resulting in battery packs shifting to Li-ion battery chemistry similar to other mobile electronics.</td>
</tr>
<tr>
<td>Li-ion batteries require additional safety considerations and battery management compared to NiCd &amp; NiMH based systems.</td>
</tr>
<tr>
<td>Brushless DC motors are preferred for higher Whr power tools for better reliability/longevity, smaller size and improved output performance.</td>
</tr>
</tbody>
</table>

*Based on LIB market trend. Estimating an average of 5 cells/pack, we divided total unit shipments of cells/year by 5 to get total unit shipments of power tools.

Source: PressureWashr March 2018 report Tool Industry Behemoths

Source: LIB market trend, alliedmarketresearch

Global Power Tools Market Share

- Stanley Black & Decker: 18%
- TTI: 28%
- Makita: 12%
- Hilti Corp.: 27%
- Robert Bosch GmbH: 10%
- Hitachi Koki: 3%
- Others: 2%
- Total: 100%

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Battery packs used in power tools & appliances

Battery management unit
- Battery protectors
- Fuse
- TVS diode
- PPTC

Cell protection module
- NTC

Bluetooth module
- ESD protection

Battery-powered appliances
Hand-held appliances
Basic power tool or appliance battery pack architecture

Legend:
- Power Line
- Signal Line

1. Battery Management Unit
   - Thermal Coupling
   - Signal Lines
   - ID Pin
   - Bluetooth Module

2. Cell Protection Module
   - Charge Discharge MOSFETs
   - Battery+ connection

3. TVS diode array
   - Battery- connection

Technology | Series
--- | ---
Fuse | Midi Fuse, BF1, 881, 688
TVS diode | SMF, SMF4L
PPTC, Fuse | nanoSMD, 0805L
Battery protectors | ITV
NTC* | KC series
TVS diode array | SP3021, SP1007

* Thermally coupled with Li-Ion cells.

Acronyms:
- NTC: negative temperature co-efficient
- MOV: metal oxide varistor
- TVS: transient voltage suppressor
- PPTC: polymeric positive temperature co-efficient

Click on the product series in the table below for more info.
## Typical products for tools & appliances battery packs

<table>
<thead>
<tr>
<th>Technology</th>
<th>Function in Application</th>
<th>Series</th>
<th>Benefits</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse</td>
<td>Protect cells from high currents due to external shorts</td>
<td>Midi Fuse, BF1, 881, 688</td>
<td>Reduces customer qualification time by complying with 3rd party safety standards such as UL/IEC</td>
<td>3rd party compliance UL/IEC, low internal resistance, shock safe, vibration resistant</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Protects battery pack from over-voltage condition due to abnormal charging conditions</td>
<td>SMF, SMF4L</td>
<td>Improves system reliability by protecting downstream components from transients on power lines</td>
<td>Excellent clamping capability</td>
</tr>
<tr>
<td>PPTC, Fuse</td>
<td>Protect cells and BMS MOSFET from high currents due to external shorts</td>
<td>nanoSMD, 0805L</td>
<td>Reduces customer qualification time by complying with 3rd party safety standards such as UL/IEC</td>
<td>Surface mountable, resettable (PPTC), compatible with lead-free solder process per IEC standards, SMD form-factor allows for compact design</td>
</tr>
<tr>
<td>Battery protectors</td>
<td>Dual overcurrent and overvoltage protection</td>
<td>ITV</td>
<td>Increases assemble efficiency</td>
<td>Surface mountable; UL and TUV certified</td>
</tr>
<tr>
<td>NTC</td>
<td>Temperature monitoring of battery pack during charging &amp; discharging cycles.</td>
<td>KC series</td>
<td>Provides accurate temperature reading for enabling safe device operation</td>
<td>Kynar insulated lead wires, small form factor, fast thermal response</td>
</tr>
<tr>
<td>TVS diode array</td>
<td>Protects IC from ESD</td>
<td>SP3021, SP1007</td>
<td>Protects end user from electrical shocks and physical harm</td>
<td>Hermetically sealed, custom designed sensitivity</td>
</tr>
</tbody>
</table>
Functional elements in power tool charger

AC input primary protection
- Fuse
- MOV
- NTC

High frequency converter & clamp
- MOSFET
- TVS diode

Secondary-side rectification
- Reverse blocking diode
Power tool charger protection architecture

AC Mains → AC Input Primary Protection Rectifier & Filter → High Frequency Converter & Clamp → Step-down Transformer → Secondary-side Rectification & Filter → Output DC Protection & Sensor → Battery Pack

Legend:
- Power Line
- Signal Line

Technology | Series
---|---
1 | Fuse
   | 5X20mm Fuse, TR, TE
   | NTC*
   | ST
   | MOV
   | LA, CIII, TMOV
2 | MOSFET
   | X2-class
   | TVS Diode
   | P6KE, P6SMB
3 | Schottky Diode
   | MBR, DST

* Thermally coupled to Li-Ion cells.

Acronyms:
- NTC: negative temperature co-efficient
- MOV: metal oxide varistor
- TVS: transient voltage suppressor
## Potential Littelfuse products for power tool charger

<table>
<thead>
<tr>
<th>Technology</th>
<th>Function in Application</th>
<th>Series</th>
<th>Benefits</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse</td>
<td>Protects power stage from overcurrent</td>
<td>5X20mm Fuse, TR, TE</td>
<td>Reduces customer qualification time by complying with third party safety standards such as UL/IEC</td>
<td>Third party compliance UL/IEC, low internal resistance, shock safe, vibration resistant</td>
</tr>
<tr>
<td>NTC</td>
<td>Protects power stage from high inrush current</td>
<td>ST</td>
<td>Improves system reliability</td>
<td>Small form factor, fast thermal response</td>
</tr>
<tr>
<td>MOV</td>
<td>Protects power unit from voltage surges such as lighting, transients</td>
<td>LA, CIII, TMOV</td>
<td>Reduces customer qualification time by complying with third party safety standards such as UL/IEC</td>
<td>High energy absorption capability: 40 J – 530 J (2 ms)</td>
</tr>
<tr>
<td>MOSFET</td>
<td>High switching speed in power supply units</td>
<td>X2-class</td>
<td>Fast response time and lower heat signature</td>
<td>Low Rds(on), dv/dt ruggedness</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Protects power unit from voltage transients</td>
<td>P6KE, P6SMB</td>
<td>Improves system reliability by protecting downstream components from transients on power lines</td>
<td>Excellent clamping capability</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Rectification and blocking in power supply units</td>
<td>MBR, DST</td>
<td>Enables the design of high efficiency power supplies</td>
<td>Ultra low forward voltage drop, high frequency operation</td>
</tr>
</tbody>
</table>
Key elements of cordless power tool

Temperature Sense
- NTC

Trigger Input Protection
- Fuse
- TVS Diode
- Reed Switch

Power Bridge Protection
- NTC

Power Bridge & Gate Driver
- MOSFET

Protect Control Sense
BLDC motor protection architecture

Click on the product series in the table below for more info

<table>
<thead>
<tr>
<th>Technology</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse</td>
<td>1206SFH, 501</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>SMAJ, SMBJ, 5KP</td>
</tr>
<tr>
<td>Reed Switch</td>
<td>MDSR-10, MDSM-10</td>
</tr>
<tr>
<td>NTC*</td>
<td>KC series</td>
</tr>
<tr>
<td>MOSFET</td>
<td>Gen2</td>
</tr>
<tr>
<td>NTC</td>
<td>KC series</td>
</tr>
</tbody>
</table>

* Thermally coupled to Li-Ion cells.

Acronyms:
NTC: negative temperature co-efficient
TVS: transient voltage suppressor

Legend:
- Green arrows: Power Line
- Blue arrows: Signal Line
Select Littelfuse products for BLDC motor protection

<table>
<thead>
<tr>
<th>Technology</th>
<th>Function in Application</th>
<th>Series</th>
<th>Benefits</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fuse</td>
<td>Protects battery and downstream controller from damage due to inrush current due to motor shorting or external shorts at contacts</td>
<td>1206SFH, 501</td>
<td>Reduces customer qualification time by complying with third party safety standards such as UL/IEC</td>
<td>Third party compliance UL/IEC, low internal resistance, shock safe, vibration resistant</td>
</tr>
<tr>
<td>TVS diode</td>
<td>Protect battery pack from voltage transients</td>
<td>SMAJ, SMBJ, 5KP</td>
<td>Improves system reliability by protecting downstream components from transients on power lines</td>
<td>Excellent clamping capability</td>
</tr>
<tr>
<td>Reed Switch</td>
<td>Provides control signal to turn on and off the motor</td>
<td>MDSR-10, MDSM-10</td>
<td>Contamination resistant, compact design</td>
<td>Switch up to 200Vdc or 0.5A at up to 10W, 12 Ohms insulation resistance</td>
</tr>
<tr>
<td>2 NTC</td>
<td>Temperature sensing of Power MOSFET</td>
<td>KC series</td>
<td>Provides accurate temperature (component/ambient) for enabling safe device operation</td>
<td>High reliability, small form factor, fast thermal response</td>
</tr>
<tr>
<td>MOSFET</td>
<td>Part of inverter of brushless DC motor for high frequency switching</td>
<td>Gen2</td>
<td>Improves system efficiency and enables compact design</td>
<td>Very low Rds(on), High current capability</td>
</tr>
<tr>
<td>NTC</td>
<td>Temperature sensing To prevent motor damage due to over-heating</td>
<td>KC series</td>
<td>Provides accurate temperature (component/ambient) for enabling safe device operation</td>
<td>High reliability, small form factor, fast thermal response</td>
</tr>
</tbody>
</table>
Corded power tools contain fewer electronic components

AC Switching
- TRIAC
Corded power tool protection opportunities

- **Technology**: TRIAC
- **Function in Application**: High power AC switching and speed control
- **Series**: Qxx25xHx/ QJxx25xHx
- **Benefits**: AC switching and efficient speed control, reduced need of heat sinking
- **Features**: High Tj (150°C), internally isolated packages (mechanically and thermally robust)

**Legend:**
- Power Line
- Signal Line
# Standards for power tool equipment

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
<th>General Scope</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC/UL 62841-1</td>
<td>Safety standards for Transportable Hand-Held Motor Operated Electric Power Tools</td>
<td>IEC 62841-1 compliance testing deals with the hazards presented by tools. The standard covers tools with rated voltage not more than 250 V for single-phase A.C. or D.C. and 480V for three-phase A.C. The rated input is not more than 3700W*</td>
<td>Global/North America</td>
</tr>
<tr>
<td>IEC 62133-2/UL 62133</td>
<td>Safety standards for Li-Ion Secondary Cells and Batteries</td>
<td>Evaluating protection during various battery fault scenarios</td>
<td>Global/North America</td>
</tr>
<tr>
<td>UL 2595</td>
<td>General Requirements for Battery-Powered Appliance</td>
<td>The standard covers the safe functioning of lithium-ion battery systems and lithium-ion cells employed in battery systems. The maximum rated voltage for appliances and battery packs is 75 Vdc</td>
<td>North America</td>
</tr>
<tr>
<td>UL 1642</td>
<td>Lithium Batteries</td>
<td>Both are Safety standard that deal with cells and small portable batteries. UL1642 deals with individual cells while UL2054 is for small rechargeable battery packs.</td>
<td>North America</td>
</tr>
<tr>
<td>UL 2054</td>
<td>Household and Commercial batteries</td>
<td></td>
<td>North America</td>
</tr>
<tr>
<td>IEC 62281</td>
<td>Safety of Primary and Secondary Lithium Cells and Batteries during transport</td>
<td>This standard specifies test methods and requirements for primary and secondary (rechargeable) lithium cells and batteries to ensure their safety during transport other than for recycling or disposal.</td>
<td>Global</td>
</tr>
<tr>
<td>JIS C8714</td>
<td>Safety Tests for Portable Li-Ion secondary cells and Batteries</td>
<td>Covers safety testing of Li-ion storage batteries (single cell and multiple cell) for portable electronic devices</td>
<td>Japan</td>
</tr>
<tr>
<td>ANSI C18.2M</td>
<td>Portable Rechargeable Cells and Batteries</td>
<td>Defines safety standards for portable cells and batteries. It is specific to two distinct chemistry systems: lithium ion and nickel</td>
<td>North America</td>
</tr>
</tbody>
</table>

* The maximum input power for single-phase is not more than 3700W.
Additional information can be found on littelfuse.com
Local resources supporting our global customers
Partner for tomorrow’s electronic systems

**Broad product portfolio**
A global leader with a broad product portfolio, covering every aspect of protection, sensing, and control

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

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

**Compliance & regulatory expertise**
To help customers in the design process to account for requirements set by global regulatory authorities

**Testing capabilities**
To help customers get products to market faster, we offer certification testing to global regulatory standards

**Global manufacturing**
High-volume manufacturing that is committed to the highest quality standards
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