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 parts, 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 littelfuse.com/disclaimer-electronics.
UPS shares similar architecture with multiple industrial and renewable energy systems

- Soft Starters
- Variable Frequency Drives
- Solar Inverter & Charge Controller
- Industrial Battery Charger
- Data Center & Telecom Power Systems
- Wind Turbine Rectifier & Inverter
- EV Charger
Energy efficiency and reliability continue to drive UPS market sales

### Market trends and drivers

**Global UPS market**
- Estimated to grow at 5% CAGR for next five years
- Need for reliable electrical energy is driving increased sales to data centers, medical, industrial, and consumer markets
- Increasing energy-efficiency requirements are causing data centers to prefer multi-mode, line-interactive UPS
- Power surges and failures are key growth drivers for UPS in Europe
- Lithium-ion batteries are the preferred energy storage system for UPS due to high energy density and long shelf life

### Global UPS market sales

- **Source:** [Global UPS Market](https://360ResearchReports.com, 2020), marketing estimates

### Data center UPS by type

- **Source:** [Data center UPS market](https://GlobalMarketInsights.com, 2019), marketing estimates
Ideal UPS type depends on system priority of key characteristics

### Energy efficiency
- **Standby**: Very high
- **Line interactive**: Very high
- **Double conversion on-line**: Medium – Power conversion causes some loss
- **Multi-mode**: Medium – Power conversion causes some loss

### Switching time
- **Standby**: High – Switching from line power to battery takes a few electrical cycles
- **Line interactive**: Low
- **Double conversion on-line**: Zero – Power always flows through inverter
- **Multi-mode**: Zero – Power always flows through inverter

### Filtering
- **Standby**: Medium
- **Line interactive**: High
- **Double conversion on-line**: Very High
- **Multi-mode**: Very High

### Cost per VA
- **Standby**: Low
- **Line interactive**: Medium
- **Double conversion on-line**: Medium
- **Multi-mode**: Medium
Littelfuse solutions for UPS

AC input
- Fuse
- MOV

AC/DC converter
- Rectifier module
- IGBT/MOSFET
- Gate driver
- Temperature sensor

DC/AC converter
- IGBT module
- Gate driver
- Temperature sensor

Bypass switch
- Thyristor module

Battery and ESS
- Fuse
- TVS diode
- Diode array
- Gate driver
- MOSFET
- Temperature sensor
Notes:
I. Double conversion on-line UPS diagram used as representative model. Other topologies will have similar solution needs at common power levels.
II. Many other fuse options available based on system attributes such as current, voltage, available fault current, surge withstand, and sensitivity of semiconductors.
III. For faster response, consider PEKE or a combination of a SIDACtor® and an MOV (P3500SCLRP + LA series).
IV. Rectifier diodes can potentially be substituted with active rectification through IGBT for improved efficiency.
V. Gate drivers may require an isolator. Contact factory for recommendations.

Acronyms:
UPS: Uninterruptible Power Supply
MOV: Metal Oxide Varistor
TVS: Transient Voltage Suppressor
SMD: Surface Mount Device

Click on the product series in the table below for more info
## Features and benefits of Littelfuse solutions

<table>
<thead>
<tr>
<th>Technology</th>
<th>Function in application</th>
<th>Product series</th>
<th>Benefits</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse</td>
<td>Overcurrent fault protection</td>
<td>PSR, JLLS, 505</td>
<td>Fast opening to protect the power conversion semiconductor components</td>
<td>Compact design; 200 kA interrupting rating; available with PCB mounts</td>
</tr>
<tr>
<td>MOV</td>
<td>Surge voltage protection</td>
<td>TMOV</td>
<td>Promotes robust operation</td>
<td>Thermally protected; high peak surge current rating up to 10 kA; wave solderable</td>
</tr>
<tr>
<td>Rectifier module</td>
<td>Rectify AC to DC</td>
<td>MDD, VUO, MDMA</td>
<td>High efficiency system operation with low heat generation</td>
<td>Improved temperature and power cycling; very low forward voltage drop; very low leakage current</td>
</tr>
<tr>
<td>IGBT + MOSFET</td>
<td>Power factor correction</td>
<td>XPT and Ultra junction X-Class</td>
<td>Low power consumption; high efficiency system operation</td>
<td>Ultra low on-resistance $R_{DS(ON)}$ and gate charge $Q_{g}$; fast body diode dv/dt ruggedness</td>
</tr>
<tr>
<td>Gate driver</td>
<td>Controls the IGBT/MOSFET</td>
<td>IXD_6xx</td>
<td>Dual outputs provide space-efficient design; high immunity to latch-up; rise/fall times less than 10 ns</td>
<td>Tight tolerance; small form factor; fast thermal response</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Monitoring rectifier for optimal performance</td>
<td>USP10976</td>
<td>Enables robust system operation</td>
<td>Tight tolerance; wide range of temperature sensing</td>
</tr>
<tr>
<td>IGBT module</td>
<td>Invert DC to AC</td>
<td>MIXA, MIXG</td>
<td>Low power loss; high efficiency operation</td>
<td>Very low gate charge; low EMI; fast and soft reverse recovery - low operating forward voltage</td>
</tr>
<tr>
<td>Gate driver</td>
<td>Controls the IGBT inverter</td>
<td>IXD_6xx</td>
<td>Dual outputs provide space efficient design; high immunity to latch-up; rise/fall times less than 10 ns</td>
<td>Tight tolerance, small form factor; fast thermal response</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Monitoring inverter for optimal performance</td>
<td>USP10976</td>
<td>Enables robust system operation</td>
<td>Tight tolerance; wide range of temperature sensing</td>
</tr>
<tr>
<td>Thyristor module</td>
<td>Switching power source</td>
<td>MCC, MCMA</td>
<td>Space saving; low thermal loss; high efficiency operation</td>
<td>Low forward voltage drop; leads suitable for PCB soldering; improved temperature and power cycling</td>
</tr>
</tbody>
</table>

See BESS block diagram ([link to page](#))
## Potential Littelfuse products for BESS 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>SMD fuse</td>
<td>Protects cells and downstream BMS components from high fault currents due to external shorts</td>
<td>501A, 881</td>
<td>Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment</td>
<td>Fast response to fault current; surface mount device</td>
</tr>
<tr>
<td>TVS diode</td>
<td>Transient voltage suppression</td>
<td>TPSMC, SZ1SMC, SZ1LSMC</td>
<td>Excellent clamping capability; fast response time</td>
<td>Meets IEC standards for ESD protection and ISO for in-vehicle transient surges</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Monitoring the system for optimal charging conditions</td>
<td>USP16673, RB</td>
<td>Promotes robust operation; allows design flexibility</td>
<td>Tight tolerance; ultra-thin</td>
</tr>
<tr>
<td>SMD or In-line fuse</td>
<td>Protect cells and BMS components from overcurrent</td>
<td>438A, 441A, 521</td>
<td>Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high-temperature environment</td>
<td>Fast response to fault current; surface mount device</td>
</tr>
<tr>
<td>TVS diode</td>
<td>Transient voltage suppression</td>
<td>TPSMB, SZ1SMB, SZP6SMB</td>
<td>Excellent clamping capability; fast response time</td>
<td>Meets IEC standards for ESD protection and ISO for in-vehicle transient surges</td>
</tr>
<tr>
<td>TVS diode</td>
<td>Transient voltage suppression</td>
<td>AQ05C</td>
<td>Excellent clamping capability; fast response time</td>
<td>Meets IEC standards for ESD protection and ISO for in-vehicle transient surges</td>
</tr>
<tr>
<td>Diode array</td>
<td>Protects sensitive electronic ICs from ESD, EFT, and voltage transient</td>
<td>TPSMA6L, SZ1SMA</td>
<td>Ensures reliability of the equipment without performance degradation</td>
<td>Meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current and clamping voltage</td>
</tr>
<tr>
<td>High-voltage fuse</td>
<td>Short-circuit and overload current protection</td>
<td>PSR, PSX</td>
<td>Lower Pt performance allows for quick response to protect devices from higher heat energy</td>
<td>High DC voltage rating up to 1500 VDC extremely fast-acting; compact form-factor</td>
</tr>
<tr>
<td>MOSFET</td>
<td>Output power control switch</td>
<td>X3 Class</td>
<td>Low power loss; design flexibility; high efficiency</td>
<td>Low R&lt;sub&gt;DS(on)&lt;/sub&gt;; fast soft recovery body; multiple mounting packages</td>
</tr>
<tr>
<td>Gate driver</td>
<td>Controls the switching MOSFETs</td>
<td>IXD_6xxS1</td>
<td>Dual outputs provide space-efficient design; high immunity to latch-up; rise/fall times less than 10 ns</td>
<td>Tight tolerance; small form factor; fast thermal response</td>
</tr>
<tr>
<td>Diode array</td>
<td>Protect CAN bus from ESD, EFT, and voltage transient</td>
<td>AO24CAN</td>
<td>Ensures reliability of the equipment without performance degradation</td>
<td>Meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current and clamping voltage</td>
</tr>
<tr>
<td>SMD fuse</td>
<td>Protects cells and BMS components from overcurrent</td>
<td>885</td>
<td>High-voltage SMD form-factor allows for compact design; ceramic body ensures compatibility with high-temperature environment</td>
<td>Fast response to fault current; surface mount device</td>
</tr>
<tr>
<td>TVS diode</td>
<td>Transient voltage suppression</td>
<td>TPSMB, TPSMC</td>
<td>Excellent clamping capability; fast response time</td>
<td>Meets IEC standards for ESD protection and ISO for in-vehicle transient surges</td>
</tr>
</tbody>
</table>
## Select standards for UPS system and ESS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
<th>General scope</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60204-1</td>
<td>Safety of machinery - Electrical equipment of machines - Part 1: General requirements</td>
<td>This part of IEC 60204 applies to electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a coordinated manner</td>
<td>Global</td>
</tr>
<tr>
<td>IEC 62061</td>
<td>Safety of machinery: Functional safety of electrical, electronic and programmable electronic control systems</td>
<td>Provides requirements that are applicable to the system level design of all types of machinery safety-related electrical control systems and for the design of non-Complex subsystems or devices</td>
<td>Global</td>
</tr>
<tr>
<td>UL 508</td>
<td>Standard for Industrial Control Equipment</td>
<td>These requirements cover industrial control devices, and devices accessory thereto, for starting, stopping, regulating, controlling, or protecting electric motors as well as industrial control devices or systems that store or process information and are provided with an output motor control function(s)</td>
<td>North America</td>
</tr>
<tr>
<td>UL 1778</td>
<td>Uninterruptible Power Systems</td>
<td>These requirements cover uninterruptible power supplies (UPS) rated 600 volts or less ac or dc that are intended for installation in accordance with the National Electrical Code, NFPA 70</td>
<td>North America</td>
</tr>
<tr>
<td>IEC 62040</td>
<td>Uninterruptible power systems (UPS) - Part 1: Safety requirements</td>
<td>This standard applies to movable, stationary, fixed or built-in UPS for use in low-voltage distribution systems, that deliver fixed frequency AC output voltage with port voltages not exceeding 1000 V AC or 1500 V DC and that include an energy storage device</td>
<td>Global</td>
</tr>
<tr>
<td>UL 9540A</td>
<td>Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</td>
<td>This document evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway</td>
<td>North America</td>
</tr>
</tbody>
</table>
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**
We help customers in the design process to account for requirements set by global regulatory authorities

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

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

Safer
Connected
Greener