Use Our Deep Experience for Your Automotive Application

About this guide
This guide provides a summary of key circuit protection consideration factors, descriptions of the technologies Littelfuse offers, and product selection tables. It is designed to help you quickly find a protection solution appropriate to your application.

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Specifications, descriptions, and illustrative material in this literature are as accurate as known at the time of publication, but are subject to changes without notice. Visit Littelfuse.com for more information.

Littelfuse: Everywhere, Every Day
Founded in 1927, Littelfuse has become the world’s most respected circuit protection brand, with well-established and growing platforms in power control and sensing technologies. Today, we are a global company, offering a diverse and extensive product portfolio—fuses, semiconductors, polymers, ceramics, relays, sensors, and more—serving the electronics, automotive, and industrial markets. Each is manufactured to exacting quality standards and backed by an unwavering commitment to technical support and customer service.

Our history of innovation, combined with our customer-first culture, drives us to collaborate with you to develop safer, more reliable products that are energy efficient and compliant with global regulations. We will partner with you to solve complex problems wherever electrical energy is used, bringing design, engineering, and technical expertise to deliver business results.

Why Choose Littelfuse
Littelfuse introduced the first of what would become a long line of automotive circuit protection technologies in the 1930s, with the design and development of the original automotive fuses. That commitment to the automotive industry continues today as vehicles have become increasingly dependent on high-powered electronics.

Littelfuse supports automotive designers with a global network of test labs and design and manufacturing facilities across four continents, including China’s second-largest semiconductor fabrication facility. Our Silicon Valley Technology Center supports the complete innovation life cycle, from new materials and product concepts to product design, prototyping, testing, and validation.

Customer Focus
A customer-first approach is at the heart of our company-wide culture, driving us to build long-lasting relationships and exceed expectations. Every day, it’s our employees who make the difference for your business. They listen to your needs and understand your challenges. They use their knowledge and expertise to develop the best solutions and solve your problems.

Application Expertise
At Littelfuse, we partner with customers to design, manufacture, and deliver innovative solutions for a wide range of markets including automotive and commercial vehicles, industrial applications, data and telecommunications, medical devices, consumer electronics, appliances, and transportation. Our expertise involves applying reliable and efficient product solutions, innovative technologies, and global resources to address technical challenges in a variety of applications. Our worldwide network of research teams focuses on product development and support, design-in programs, and application testing in our global labs.

Operational Excellence
With our global manufacturing footprint, Littelfuse is firmly committed to manufacturing quality products at a competitive price. We build quality into our products and services, striving for zero defects in everything we do, thereby reducing cost and increasing your total satisfaction. We strive to exceed your expectations every day.

Quality Assurance
Our global manufacturing facilities abide by strict quality assurance requirements and hold the following quality management system registrations:
- ISO 9001
- ISO14001
- IATF 16949

Protect. Control. Sense.
Littelfuse offers leading technologies in circuit protection, power control, and sensing. We continue to expand our broad and diverse portfolio of products into adjacent markets, including Power Semiconductors, heavy-duty Switches, Magnetic, Optical, Electromechanical, and Temperature Sensors as well as other products that provide safe control and distribution of electrical power.
Electrical Threats and New Automotive Technologies

THREAT: ELECTROSTATIC DISCHARGE (ESD)
ESD is characterized by fast rise times and high peak voltages and currents up to 30A, which can melt silicon and conductor traces. Even when ESDs don’t cause catastrophic failures, electrical currents due to ESD can change the state of internal logic, causing a system to latch up and behave unpredictably or cause corruption of a data stream. Without adequate protection, ESD can damage control units, infotainment electronics, sensors, fuel injectors, valves, motors, powertrains, and dozens of other components. Sometimes, a component or circuit is damaged by ESD, creating latent defects that later progress to premature failures.

TVS Diode Arrays
Because of their high-speed response to overvoltages, TVS Diode Arrays are widely used for ESD protection in automotive electronics. Automotive-qualified SPA® TVS Diode Arrays from Littelfuse are available in a range of compact surface-mount packages to fit into any layout.

THREAT: SWITCHING LOADS IN POWER ELECTRONICS CIRCUITS
In modern automotive designs, all on-board electronics are connected to the battery and the alternator. However, the output of the alternator is unstable and requires further conditioning before it can be used to power the vehicle’s other systems. During the powering or switching of inductive loads, the power is temporarily interrupted, and unwarranted voltage spikes or transients are generated. If left unchecked, these transients would be transmitted along the power line and into the electronic modules.

Varistors
Automotive-qualified Metal Oxide Varistors (MOVs) and Multilayer Varistors (MLVs) protect against voltage transients induced by load dump and other transient events. When exposed to high-voltage transients, the varistor impedance changes by many orders of magnitude—from a near open-circuit to a highly conductive level—clamping the transient voltage to a safe level. Choose from radial-leaded MOVs in disc sizes from 5mm to 20mm. Also, surface-mounted MLVs are available.

THREAT: OVERLOADS/SHORT-CIRCUIT CURRENTS
Sustained overloads will cause circuit components to overheat, potentially leading to catastrophic and uncontrolled failures of the vehicle’s electrical system. Short circuits can surpass the capabilities of the wires, connectors, etc., in the power circuit, which can also lead to uncontrolled failures or possibly a thermal event.

Fuses
Automotive Fuses protect components or circuits by melting under overcurrent conditions to interrupt current flow. In addition to withstanding rapid temperature cycles and vibration, they must offer long-term stability and AEC-Q test compliance. Littelfuse offers an unparalleled range of automotive Fuses, from cartridge and blade styles to surface-mount chip Fuses.

Resettable PPTC Overcurrent Protection Devices
Littelfuse Polymeric Positive Temperature Coefficient (PPTC) devices are widely used in automotive applications like wiring harness and network protection, communication and infotainment systems, and EV battery management systems. Unlike Fuses, these devices provide resettable protection for automotive electronics against damage from harmful overcurrent surges. Bladed, leaded, and surface-mount form factors are available for automotive applications.

OPPORTUNITY: ELECTRIFYING THE VEHICLES OF TOMORROW
Researchers predict that by 2025, a typical high-end vehicle will contain more than $6,000 worth of electronics. The growing interest in self-driving vehicles, vehicle-to-vehicle and vehicle-to-infrastructure communications, and on-board safety, convenience, and environmental features ensures that the sheer number of electronic components per vehicle will continue to expand rapidly. Additionally, as hybrid-electric vehicles become increasingly popular, power semiconductors will be critical to the next generation of Battery Management Systems and on-board/off-board charging systems.

Power Semiconductors
Power semiconductor devices enable the next generation of vehicles by managing power flexibly. Fast-switching SiC technology increases power density and energy efficiency in systems like on-board battery chargers. The Littelfuse power semiconductor portfolio includes Thyristors, Rectifiers, Fast Recovering Diodes, IGBTs, and wide band gap devices.
## Automotive Applications in Modern Vehicles

The Littelfuse portfolio of AEC-Q101-qualified (TVS diodes and diode Arrays) and AEC-Q200-qualified (varistors, multilayer varistors, and PPTCs) components helps to protect the growing number of electronic applications in modern vehicles.

From ultra-low capacitance Diode Arrays for ESD protection of high-speed signal lines, including Ethernet, USB 3.1, and HDMI, to passive system-level protection of high-voltage and high-energy transients, Littelfuse has the solutions and expertise to meet your technical and application challenges.

### COMMUNICATION & INFOTAINMENT SYSTEMS
- Radio
- Power Audio
- GPS Module
- Satellite Navigation
- Portable Navigator
- Navigation System
- Telematics Box
- Car Multimedia

### NEW ENERGY CAR
- Gas Electric
- Fuel Cell Electric
- Diesel Electric
- Li-Ion and NiMH Battery Electric
- Ultracapacitors
- Battery Management System (BMS)

### POWERTRAIN SYSTEMS
- Automatic Cruise Control (ACC)
- Electronic Control Unit (ECU)
- Turbo Charger
- Selespeed®
- Transmission Control Unit (TCU)
- Battery Charging
- Injection
- GDI

### COMMUNICATION & INFOTAINMENT SYSTEMS
- CAN Bus
- LIN Bus
- FlexRay®
- MOST®
- Bluetooth®
- BroadR-Reach®
- Safe-By-Wire®
- Central Body Module
- Lighting Power Window
- Retracting Mirror
- Wiper
- Dashboard
- Climate Control
- Keyless Entry
- Seat Control
- Park Assistance

### CHASSIS & SAFETY SYSTEMS
- Active Suspension
- Tire Pressure Monitoring System (TPMS)
- Electric Power Steering (EPS)
- Seat Belt Pretensioning
- Precrash
- Battery Disconnect
- Antilock
- Stability Control
- Brake Control
- DC Power Supply
- Air Bag
- ABS
- Radar

### ADVANCED DRIVER ASSISTANCE SYSTEMS
- Night Vision
- Pedestrian Avoidance
- Lane Departure Sensing
- Adaptive Cruise Control
- Vehicle-to-Vehicle (V2V) Communication
- Interior Camera – Driver Monitoring
- Exterior Camera – Front View
- Exterior Camera – Rear View Park Assist
- Blind Spot Detection
- Side Impact Assist
- Automated Headlight Control

### NETWORK SYSTEMS & BODY
- CAN Bus
- LIN Bus
- FlexRay®
- MOST®
- Bluetooth®
- BroadR-Reach®

### POWERTRAIN SYSTEMS
- Automatic Cruise Control (ACC)
- Electronic Control Unit (ECU)
- Turbo Charger
- Selespeed®

### Ignition IGBTs
- Switching semiconductor devices for ignition circuits

### SM24CANA Diode Arrays
- Safeguard automotive CAN Bus from ESD damage

### TPSMD TVS Diodes
- Protect electronic circuits against system-generated transients
- Protects high-frequency and RF circuits from ESD

### AXGD Series
- Designed to suppress destructive surges and ESD

### AUML & Auto MLA Varistors
- Suppress high-energy transients in AC and DC circuits

### AUMOV® Varistors
- Surface Mount PPTCs
- Provide safety protection against overcurrent events

### Surface Mount Fuses
- Designed to suppress destructive surges and ESD

Littelfuse experts support customers’ designs in accordance with worldwide automotive safety standards. By contributing their own experience to the development of new standards, Littelfuse engineers help to ensure the safety and reliability of the next generation of circuit protection products.

Littelfuse engineers help customers understand which standards apply in terms of both the application itself and the geographical location for which it is designed, as well as offer guidance on how to meet those standards. Littelfuse offers a broad line of circuit protection devices certified compliant with these standards.

- **Transient surges**: JASO and ISO 7637-2 (Surge) test
- **Electrical disturbance by conduction and coupling**: ISO 7637-2
- **Electrical disturbances from electrostatic discharge**: ISO 10605
- **Environmental conditions and testing for electrical and electronics equipment**: ISO 16750-2
- **Load dump, switching transients, and ESD threats**: SAE J1113, GM 9105, ES-F2af-1316-AA Ford (Visteon)

Electrical component qualification:
- **AEC-Q101**: failure-mechanism based stress test qualification for discrete semiconductors in automotive applications
- **AEC-Q200**: stress test qualification for passive electronic devices

*The marks BroadR-Reach®, FlexRay, MOST, Bluetooth, Safe-By-Wire, and Selespeed are the properties of their respective owners.*
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<td>Bluetooth</td>
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<td>TCU (Telematics Control Unit)</td>
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<td>BCM (All Body Control Module)</td>
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<td>EV/HEV DC/DC Converter</td>
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<td>Battery Management System</td>
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<td>Battery Disconnect (High Voltage)</td>
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<td>DC/DC Converter</td>
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</table>

* The marks BroadR-Reach®, FlexRay, MOST, Bluetooth, Safe-By-Wire, and SelsPEED are the properties of their respective owners.
## Automotive Electronics Circuit Protection Applications Matrix

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</tbody>
</table>

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ENERGY STORAGE SYSTEM

The energy storage system, which includes the battery management system, stores and supplies electric power for all vehicle needs. Obviously critical, this system needs protection from a wide range of electrical threats, such as high-fault currents, voltage transients, overcurrent, and overloads. Each threat is best countered with the right type of circuit protection technology.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Application</th>
<th>Series Name</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>881A, 885A</td>
<td>Tested to new AECQ specification, fast response to fault current, surface mount device</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TPSMC, TPSMC</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for automotive transient surges</td>
</tr>
<tr>
<td>SMD or Inline Fuse</td>
<td>Protects cells and BMS components from overcurrent</td>
<td>437A, 438A</td>
<td>Tested to new AECQ specification, fast response to fault current, surface mount device</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TPSMB, TPSMB</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for automotive transient surges</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protects sensitive electronic ICs from ESD, EFT and voltage transient</td>
<td>TPSDA, TPSDA</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for automotive transient surges</td>
</tr>
<tr>
<td>High-Voltage Fuse</td>
<td>Short circuit protection, overload circuit protection</td>
<td>SHEV, 20HEV</td>
<td>Bolt down form factor, high breaking capacity, qualified to ISO 8820 standard</td>
</tr>
<tr>
<td>Gate Driver</td>
<td>Controls the switching MOSFETs</td>
<td>IXD 600SI</td>
<td>Tight tolerance, small form factor, fast thermal response</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protects CAN Bus from ESD, EFT and voltage transient</td>
<td>TPSDA, TPSDA</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for automotive transient surges</td>
</tr>
<tr>
<td>SMD Fuse</td>
<td>Protects cells and BMS components from overcurrent</td>
<td>881A, 885A</td>
<td>Tested to new AECQ specification, fast response to fault current, surface mount device</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TPSMC, TPSMC</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for automotive transient surges</td>
</tr>
</tbody>
</table>

BATTERY MODULE

Inside the battery pack is a number of battery modules made up of individual battery cells. This architecture dictates that layers of circuit protection are required. At the module level, the battery module and cable should be protected from overcurrent and from overloads between power-sense lines. The electronics should be defended against voltage transients, and the CAN and other communication buses should be safeguarded from ESD and voltage transients.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Applications</th>
<th>Series Name</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Voltage Fuse</td>
<td>Protects battery pack module and cable from overcurrent</td>
<td>SHEV, 20HEV</td>
<td>Third party compliance UL/ISO, low internal resistance, shock safe, vibration resistant</td>
</tr>
<tr>
<td>Low-Voltage Fuse</td>
<td>Analog front-end protection of user and environment in case of external short, overload, transient, power-sense line</td>
<td>SHEV, 20HEV</td>
<td>Surface mountable, compatible with lead-free solder process per IEC standards, high reliability</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Protect sensitive electronic components from voltage transients</td>
<td>TPSMB</td>
<td>500W peak pulse capability, compatible with lead-free solder reflow temperature profile</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect CAN Bus sensitive electronic ICs from ESD, EFT and voltage transient</td>
<td>TPSDA, TPSDA</td>
<td>AEC-Q101 qualified, low capacitance, low leakage current</td>
</tr>
</tbody>
</table>
ON-BOARD BATTERY CHARGER

Hybrid and electric vehicle batteries can be recharged from standard power outlets by using an AC-DC converter system, or directly from DC power that is covered outside of the vehicle for faster charging. Design challenges include protecting against overcurrents, overvoltage, and ESD, as well as controlling switching of the input rectifiers. Littelfuse offers a broad range of High Voltage Fuses, Varistors, GDTs, Switching Thyristors and TVS Diodes and Diode Arrays to address these threats.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Application</th>
<th>Series Name</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuses</td>
<td>Short circuit protection</td>
<td>525*, 526*, 527*</td>
<td>High voltage, ceramic body ensures compatibility with high temperature environment</td>
</tr>
<tr>
<td>Metal Diode Varistor (MOV)</td>
<td>Lighting and system transient surge</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Wide range of surge current ratings, slim design and lead options</td>
</tr>
<tr>
<td>GDT</td>
<td>Ensure electrical isolation between line, neutral and ground</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Ragged, high surge current based on ceramic tube design, low leakage current</td>
</tr>
<tr>
<td>SIDACtor</td>
<td>Lighting and system transient surge</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Surface mount form factor, semiconductor-based design provides no wear-out capability</td>
</tr>
<tr>
<td>Thyristor</td>
<td>Rectification</td>
<td>TPSMB, TPSMA6L, TPSMF4L</td>
<td>Compact TO-2044 and surface mount TO-263 form factors, 18kW or 25A (max)</td>
</tr>
<tr>
<td>Gate Driver</td>
<td>Controls the switching IGBTs</td>
<td>IXD_6xxSI, IX4340NE</td>
<td>Tight tolerance, small form factor, fast thermal response</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Active clamping</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Small fuse factor D0480 AA package, low clamping voltage, products are available with voltage ratings from 150V-650V. For more information on Active Clamp see here</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection of the gate input</td>
<td>TPSMB, TPSMA6L, TPSMF4L</td>
<td>Tight tolerance, small form factor, fast thermal response</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection of the gate input</td>
<td>TPSMB, TPSMA6L, TPSMF4L</td>
<td>Small fuse factor D0480 AA package, low clamping voltage, products are available with voltage ratings from 150V-650V. For more information on Active Clamp see here</td>
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<tr>
<td>Fuses</td>
<td>Short circuit protection</td>
<td>525*, 526*, 527*</td>
<td>High voltage, ceramic body ensures compatibility with high temperature environment</td>
</tr>
<tr>
<td>Metal Diode Varistor (MOV)</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Wide range of surge current ratings, slim design and lead options</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
</tbody>
</table>

Legend:
- Power Line
- Signal Line

* Please contact us for more details

TRACTION MOTOR INVERTER

The traction motor inverter changes DC current from the battery into the AC current needed to drive the traction motor of an electric or hybrid electric vehicle. Littelfuse offers a variety of components across this system, starting with a fuse on the power supply and ending with thermal protection on the motor.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Application</th>
<th>Series Name</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>SMD Fuse</td>
<td>Short circuit protection</td>
<td>525*, 526*, 527*</td>
<td>High voltage, ceramic body ensures compatibility with high temperature environment</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect CAN Bus from ESD, EFT and voltage transient</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection of the gate input</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Gate Driver</td>
<td>Controls the switching IGBTs</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Active clamping</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Fuses</td>
<td>Short circuit protection</td>
<td>525*, 526*, 527*</td>
<td>High voltage, ceramic body ensures compatibility with high temperature environment</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Transient Voltage Suppression</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>AEC-Q101 qualified, meets surge current levels specified under IEC 61644-4-1, ESD10050B, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Thermal Protector</td>
<td>Thermal protection for MOSFETs</td>
<td>TVS D0480P/01, TVS D0480P/02</td>
<td>Surface mountable form factor, compatible with standard reflow process, breaks current flow during overtemperature condition</td>
</tr>
</tbody>
</table>

Legend:
- Power Line
- Signal Line

* Please contact us for more details
The DC/DC converter changes the high voltage from the battery to a lower level of voltage, which is needed by a wide range of onboard systems: 12 V loads, including lighting, sensors, and entertainment, and 48 V loads, including heating, powertrain, and air conditioning. Littelfuse IGBT Gate Drivers control the switching MOSFETs for energy-efficient power conversion. Power semiconductor devices are vulnerable to electrical threats, which is why circuit protection is particularly important.

**DC/DC CONVERTER**

**BATTERY DISTRIBUTION UNIT**

A battery distribution unit is like the vehicle’s junction/panel box, delivering power to the many systems that need it. In electric vehicles, the unit relies on high-current, high-voltage fuses and contactors. Drawing upon its deep experience in the automotive industry, Littelfuse provides both fuses and contactors that are reliable and safe for this emerging application.
ACTIVE CLAMPING

Insulated Gate Bipolar Transistors (IGBTs) are widely used in power inverters, electric vehicle chargers, and motor control because of their ease of use and their high-voltage and current driving capabilities. Active clamping switching technology offers a solution that illustrates how modern, high-power IGBTs can be used with reliability, especially in high-speed railway and automotive traction applications. A high-voltage TVS diode is a critical component for IGBT active clamping during an IGBT turn-off event, and helps in operating an IGBT in a safe and active mode.

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IGNITION SYSTEM

The efficiency of gasoline engines and consequently their mileage and emissions are dependent on the performance of the ignition system. The latter must be protected against variety of threats, including load dumps, feedback loops, and overcurrents. In addition to high-performance Ignition IGBTs, Littelfuse offers a broad portfolio of protection devices like TVS Diodes, MLVs, PPTCs, and Fuses.
MOTOR CONTROL

As mechanical/hydraulic actuators are replaced with electric motors, such as those for electric parking, braking, seat modules, and mirrors, motor control circuit protection is critical to a vehicle’s overall reliability. Potential threats include load dump, overcurrents, surges, and ESD. Littelfuse offers a wide range of TVS Diodes and Diode Arrays, MLVs, MOVs, and PPTCs to protect motor control applications.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Application</th>
<th>Series Name</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVS Diode</td>
<td>Load dump protection</td>
<td>SLD8S</td>
<td>TVS Diode for ISO16750 5a/5b load dump protection</td>
</tr>
<tr>
<td>Multilayer Varistor (MLV)</td>
<td>Load dump protection</td>
<td>AUML Multilayer Varistor with load dump energy rating per SAE specification J1113</td>
<td></td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Standard surge protection</td>
<td>SZ1SMA, SZ1SMB, TPSMA6L, TPSMB, TPSMC, TPSMD</td>
<td>TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W</td>
</tr>
<tr>
<td>PPTC</td>
<td>Overcurrent protection</td>
<td>miniASMD, ASMD, miniASMDCH</td>
<td>Resettable SMD overcurrent protection up to 3A</td>
</tr>
<tr>
<td>Metal Oxide Varistor (MOV)</td>
<td>Overvoltage protection</td>
<td>AUMOV</td>
<td>Radial-leaded MOV with up to 10KA surge current and 2 W insulation voltage capability up to 125°C</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection</td>
<td>AQ1003, AQ1005, SP1326</td>
<td>Industry standard solution for ESD protection up to 2A</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Overvoltage protection</td>
<td>TPSMB, TP6KE</td>
<td>TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Load dump protection</td>
<td>SLD8S</td>
<td>TVS Diode for ISO16750 5a/5b load dump protection</td>
</tr>
</tbody>
</table>

ENGINE COOLING SYSTEM

Engines depend on a steady flow of cooling fluid to maintain optimal performance. Engine cooling systems need protection against threats, such as load dump, surges, ESDs, and overheating. The growing range of Littelfuse solutions includes TVS Diodes and Diode Arrays, MLVs, MOVs, Schottky Diodes, and SMD PPTCs.

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<tr>
<td>TVS Diode</td>
<td>Load dump protection</td>
<td>SLD8S</td>
<td>TVS Diode for ISO16750 5a/5b load dump protection</td>
</tr>
<tr>
<td>Multilayer Varistor (MLV)</td>
<td>Load dump protection</td>
<td>AUML Multilayer Varistor with load dump energy rating per SAE specification J1113</td>
<td></td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Standard surge protection</td>
<td>SLD8S, TPSMA6L, TPSMB, TPSMD</td>
<td>TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Reverse polarity protection</td>
<td>TPSMB</td>
<td>Ultra-low V, Schottky Barrier Prevents the general requirements of automotive applications by providing high temperature capability, low leakage, and low forward voltage drop up to 100°C and 18A</td>
</tr>
<tr>
<td>Diode Array</td>
<td>PMW (IO) protection</td>
<td>AQ1003, AQ1005, SP1326</td>
<td>General purpose ESD Diodes in multiple package options</td>
</tr>
<tr>
<td>Diode Array</td>
<td>LIN bus ESD protection</td>
<td>TPSMB</td>
<td>Industry standard solution for ESD and surge protection for LIN bus</td>
</tr>
<tr>
<td>Metal Oxide Varistor (MOV)</td>
<td>Switching element protection</td>
<td>TPSMB</td>
<td>Radial-leaded MOV up to 15KA surge current and 2 W isolation voltage capability up to 125°C</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Standard surge protection</td>
<td>TPSMB</td>
<td>TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W</td>
</tr>
</tbody>
</table>
INFOtainment and Navigation

Entry-level cars today integrate advanced electronic systems that were once more typical of high-end cars, including infotainment, telematics, and connectivity. Potential threats to these advanced systems include overcurrents, ESD, and surges. Littelfuse delivers comprehensive protective solutions, including SMD Fuses, SMD PPTCs, TVS Diodes and Diode Arrays, MLVs, and XTREME-GUARD™ ESD Suppressors.

Vehicle Communication

V2V and V2I will provide new levels of safety and efficiency by sharing data on vehicle locations and speed/direction, as well as receiving information from smart traffic signals. On-board power and communication circuits in these systems need overcurrent, ESD, and surge protection using Fuses, PPTCs, TVS Diodes and Diode Arrays, MLVs, and Polymer ESD Suppressors.
**EMERGENCY CALL (eCALL)**

In a crash, an eCall-equipped car will automatically call the nearest emergency center to summon help. Potential electrical threats to this system include load dump, overcurrents, surges, and ESD. To ensure eCall systems operate at peak performance, Littelfuse offers protection devices like TVS Diodes and Diode Arrays, MLVs, MOVs, SMD Fuses, SMD PPTCs, and XTREME-GUARD™ ESD Suppressors.

**Technology Application Series Name**

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<tbody>
<tr>
<td>SMD Fuse</td>
<td>Short circuit protection</td>
<td>437A, 438A</td>
<td>Tested to new AECQ specification, fast response to fault current, surface mount device</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Overvoltage protection</td>
<td>SLD8S, SZ1SMA, SZ1SMB</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for load dump protection</td>
</tr>
<tr>
<td>Multilayer Varistor (MLV)</td>
<td>Reverse blocking/output rectification</td>
<td>MLA</td>
<td>AEC-Q200 qualified, load dump energy rated per SAE specification J1113, surface mount device</td>
</tr>
<tr>
<td>Battery Strap PPTC</td>
<td>Overcurrent protection for battery</td>
<td>LSP380*, LR4, SRP</td>
<td>AEC-Q200 qualified, multiple current and size for selection</td>
</tr>
<tr>
<td>Diode Array</td>
<td>CAN Bus ESD protection</td>
<td>AQ24CANA</td>
<td>AEC-Q101 qualified, meets ESD protection levels specified under IEC 61000-4-2, ISO10605, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Diode Array</td>
<td>LIN Bus ESD protection</td>
<td>AQ24-01FTG</td>
<td>AEC-Q101 qualified, low clamping voltage and leakage current</td>
</tr>
<tr>
<td>Diode Array</td>
<td>FlexRay Bus ESD protection</td>
<td>AQ24CANFD</td>
<td>AEC-Q101 qualified, low clamping voltage and leakage current</td>
</tr>
<tr>
<td>Diode Array</td>
<td>High-speed serial link ESD protection</td>
<td>AQ3045</td>
<td>AEC-Q101 qualified, low capacitance 0.35pF and leakage current 100nA, small package</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection of multiple sensor fusion inputs like GPS, lidar, radar, and camera</td>
<td>AQ3400</td>
<td>AEC-Q qualified, low capacitance, low leakage current, small form factor μDFN</td>
</tr>
</tbody>
</table>

**SENSOR FUSION**

As designs advance closer to Level 4 and 5 self-driving vehicles, sensor data from cameras, radar, LiDAR, and GPS are becoming centralized for more-efficient processing and decision making. Protect signal lines from ESD and power lines from voltage transients and reverse polarity conditions. Littelfuse offers a broad range of protection devices including TVS Diodes, Schottky Diodes, and Diode Arrays.

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<tr>
<td>TVS Diode</td>
<td>Overvoltage protection for the power supply</td>
<td>437A, 438A</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ISO for load dump protection</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Reverse blocking/output rectification</td>
<td>DST</td>
<td>Ultra-low Vf, high temperature capability, low leakage, low forward voltage drop to 100V and 10A</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Designed to provide protection against ESD, CDE, EFT, and lightning induced surges for high-speed data lines</td>
<td>439D, 440D</td>
<td>AEC-Q qualified, low capacitance (1.0pF, 2.5pF respectively), low leakage current, small form factor μDFN</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect CAN Bus against ESD protection</td>
<td>AQ24CANA</td>
<td>AEC-Q101 qualified, low clamping voltage and leakage current</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect CAN Bus against ESD and surge transients</td>
<td>AQ24-01FTG</td>
<td>AEC-Q101 qualified, low clamping voltage and leakage current</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect FlexRay Bus against ESD and surge transients</td>
<td>AQ24CANFD</td>
<td>AEC-Q101 qualified, low clamping voltage and leakage current</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protect high-speed serial link against ESD and surge transients</td>
<td>AQ3400</td>
<td>AEC-Q101 qualified, low capacitance, low leakage current, small form factor μDFN</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection of multiple sensor fusion inputs like GPS, lidar, radar and camera</td>
<td>AQ3400</td>
<td>AEC-Q qualified, low capacitance, low leakage current, small form factor μDFN</td>
</tr>
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*S* Please contact us for more details.
**RADAR SYSTEM**

Vehicle radar has the crucial task of detecting the speed, distance, and direction of objects and then communicating that data to systems used for parking, emergency braking, and self-driving. Signal lines should have ESD protection, and the power supply should be protected from short circuits, overcurrents, and overvoltage. Automotive qualified components from Littelfuse include fuses, PPTCs, TVS Diodes, Diode Arrays, and Polymer ESD Suppressors.

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<td>SMD Fuse</td>
<td>Short circuit protection</td>
<td>437A, 438A</td>
<td>Tested to new AECQ specification, fast response to fault current, surface mount device</td>
</tr>
<tr>
<td>SMD PPTC</td>
<td>Reverse blocking/current restriction</td>
<td>miniASMD, ASMD</td>
<td>AEC-Q200 qualified, small footprint 2029/1812 size</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Overvoltage protection for the power supply</td>
<td>OVERVOLT</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ESL for load dump protection</td>
</tr>
<tr>
<td>Diode Array</td>
<td>ESD protection for waveform generator</td>
<td>DST, DPC, APD</td>
<td>AEC-Q101 qualified, low capacitance, low leakage current, small form factor</td>
</tr>
<tr>
<td>Diode Array</td>
<td>Protects CAN Bus against ESD protection</td>
<td>AQ3045, AQ24CANA, AQ24CANFD</td>
<td>AEC-Q101 qualified, meets ESL protection levels specified under IEC 61000-4-2, ISO11451, low leakage current and clamping voltage</td>
</tr>
</tbody>
</table>

**CAMERAS**

External cameras support ADAS functions like Lane Departure Warning, while interior cameras support eye tracking to prevent accidents due to drowsiness of the driver. In addition to protection against common electrical threats, data and communication buses require protection that does not interfere with high-frequency video signals. Littelfuse solutions include TVS Diodes and Diode Arrays, MLVs, Schottky Diodes, and SMD PPTCs.

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<tr>
<td>SMD PPTC</td>
<td>Reverse blocking/current restriction</td>
<td>miniASMD, ASMD</td>
<td>AEC-Q200 qualified, small footprint 2029/1812 size</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Load dump protection</td>
<td>SZ1SMB, SLD8S</td>
<td>AEC-Q101 qualified, meets IEC standards for ESD protection and ESL for load dump protection</td>
</tr>
<tr>
<td>Multilayer Varistor (MLV)</td>
<td>CAN/Bus ESD protection</td>
<td>AUML, MLA Auto</td>
<td>AEC-Q200, load dump energy rated per SAE specification J1113, surface mount device</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Reverse polarity protection</td>
<td>OVERVOLT</td>
<td>AEC-Q101 qualified, low capacitance, low leakage current, small form factor</td>
</tr>
<tr>
<td>Diode Array</td>
<td>CAN/Bus ESD protection</td>
<td>AQ3045, AQ24CANA, AQ24CANFD</td>
<td>AEC-Q101 qualified, meets ESL protection levels specified under IEC 61000-4-2, ISO11451, low leakage current and clamping voltage</td>
</tr>
<tr>
<td>Diode Array</td>
<td>High-speed ESD protection</td>
<td>AQ3045, AQ24CANA, AQ24CANFD</td>
<td>AEC-Q101 qualified, low capacitance, low leakage current, small form factor</td>
</tr>
</tbody>
</table>

Legend:
- **Power Line**
- **Signal Line**

Image Sensor

Control Unit (DSP)

Ethernet Transceiver

CAN Transceiver

FlexRay

CAN

Ethernet

Power Line

Signal Line

Transceiver

Rx

Tx

Legend:
- **Power Line**
- **Signal Line**

Multicore Micro-Controllers

Waveform Generator

Radar Receiver

Radar Transmitter

Digital Frontend

Power Supply
REMOTE KEYLESS ENTRY

Remote keyless entry systems include the on-board circuitry that receives signals from a remote “fob” and unlocks the doors, sounds an alarm, starts the engine, etc. These systems are exposed to electrical threats on both the powered circuits and the communication lines. Protection includes Fuses, TVS Diodes and Diode Arrays, MOVs, MLVs, and ESD Suppressors.

![Remote keyless entry system diagram]

LIGHTING – INSIDE CABIN

Individual user settings and automatic dimming based on external light intensity are increasingly common in modern interior lighting systems. Designers must guard against load dump, surges, ESD, overcurrents, and other threats. Choose resettable PPTCs for thermal protection of LEDs; MLVs, and Diode Arrays offer ESD protection for user controls.

![Interior lighting system diagram]
LIGHTING – HEADLAMPS

Advanced headlamps use LEDs for roadway illumination as well as motors to level, swivel, and shutter the high and low beams. Common threats include load dump, surges, ESD, and short circuits. Solutions include SMD Fuses, TVS Diodes and Diode Arrays, MLVs, and Schottky Diodes.

TESTING CAPABILITIES

Environmental
- Acceleration
- Die Shear
- Leak Detection
- Mechanical Shock
- Resistance to Soldering Heat (Dip, Reflow, Wave)
- Resistance to Solvents
- Solderability
- Terminal Strength (Pash, Pull, Bend)
- Vibration
- Wetting Balance
- Wire Pull

Physical-Mechanical Characteristics
- BCI
- Capacitance
- EFT
- ESD
- Impedance
- Isolation Resistance
- LV
- Life
- Lightning Surge
- Overload
- Parametric Tests
- Power-Cross
- Power Cycling
- Ring Wave
- R-T

Electrical
- S-Parameter Measurements (Insertion Loss, Isolation, Reflection)
- Short Circuit
- Step Current
- Surface Resistivity
- Surge
- TDR (Eye Diagram)
- Telecom
- Thermal Cut-Off
- Time-to-Trip
- TLP
- Transient
- Trip Cycle
- Trip Endurance
- Voltage Drop

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Global Lab Capabilities

You need to be certain that your products live up to the highest standards for performance, reliability, safety, and regulatory compliance. Working with Littelfuse, you have access to dedicated application engineers who partner with you to provide expert design consultation, perform comprehensive tests simulating the harshest environments, and confidentially evaluate the results in consultation with you.

Legend:
- Power Line
- Signal Line

Table:

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<tr>
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</thead>
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<tr>
<td>TVS Diode</td>
<td>Level shift protection</td>
<td>TPSMB6L, TPSMB6MB</td>
<td>TVS Diode for ISO16750 High side level shift protection</td>
</tr>
<tr>
<td>Multilayer Varistor (MLV)</td>
<td></td>
<td>TPSMA6L, TPSMA6MB</td>
<td>TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 2000W</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>Standard surge protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Voltage suppression/Venture up to 120Vdc and 65kV ESD capability</td>
</tr>
<tr>
<td>SMD PPTC</td>
<td>Reverse polarity protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Nontabulate SMD overcurrent protection up to 1A</td>
</tr>
<tr>
<td>Schottky Diode</td>
<td>Freewheeling diode</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Ultra fast Schottky Diode Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage, and low forward voltage drop up to 1500 and 10A</td>
</tr>
<tr>
<td>Diode Array</td>
<td>CAN Bus ESD protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Industry standard solution for ESD protection for CAN Bus</td>
</tr>
<tr>
<td>Diode Array</td>
<td>LIN Bus ESD protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Industry standard solution for ESD and surge protection for LIN Bus</td>
</tr>
<tr>
<td>SMD Fuse</td>
<td>Short Circuit protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>High F-P SMD Fuse with ratings up to 350V and 20A</td>
</tr>
<tr>
<td>LED Protector</td>
<td>Open circuit and overvoltage protection</td>
<td>TPSMA6L, TPSMA6MB</td>
<td>Provide a switching electronics short path when a single LED in an LED array fails as an open circuit and can also be used for overvoltage protection in normal mode</td>
</tr>
</tbody>
</table>

Disclaimer: Littelfuse products are not designed for, and shall not be used for, any purpose (including, without limitation, automotive, military, aerospace, medical, life-saving, life-sustaining or nuclear facility applications, devices intended for surgical implant into the body, or any other application in which the failure or lack of desired operation of the product may result in personal injury, death, or property damage) other than those expressly set forth in applicable Littelfuse product documentation. Literature printed by Littelfuse shall be deemed void for products used for any purpose not expressly set forth in applicable Littelfuse documentation. Littelfuse shall not be liable for any claims or damages arising out of products used in applications not expressly intended by Littelfuse as set forth in applicable Littelfuse documentation. The sale and use of Littelfuse products is subject to Littelfuse Terms and Conditions of Sale, unless otherwise agreed by Littelfuse.
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