Littelfuse®

Expertise Applied | Answers Delivered

Automotive Electronics

APPLICATIONS GUIDE

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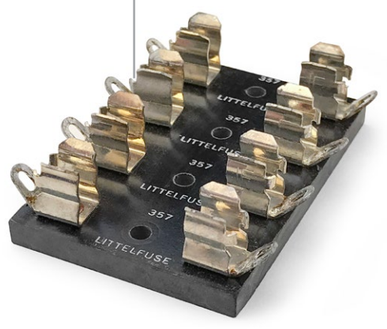
Littelfuse: A History of Automotive Innovation

1930 Littelfuse invents the first automotive fuse

CONTENTS

1950 Introduces industry's first centralized under-dash fuse block



1976 The first blade-type ATO (Autofuse®) Fast Acting Fuse, now considered the global standard

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.

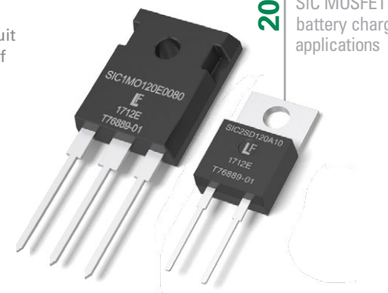
ESTABLISHED INFRASTRUCTURE

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.

INVESTED IN THE FUTURE

In addition to our comprehensive circuit protection offering and growing line of sensing solutions, our investments in Monolith Semiconductor and ON Semiconductor allow us to take our place among power semiconductor suppliers for the automotive market.

2017 Develops 1200V SiC MOSFET for battery charging applications



Littelfuse Automotive Milestones

1930 Littelfuse introduces first automotive fuses

1950 Introduces automotive switches and relays

First centralized under-the-dash fuse block for automotive industry

1976 The first blade-type ATO (Autofuse®) Fast-Acting Fuse, now considered the global standard

1991 MEGA® Automotive Fuse for higher current applications

1996 First circuit protection manufacturer to receive QS 9000 certification

1999 Named "Best Electrical Component Supplier" by *Automotive Industry* magazine

2011 Z-Case MasterFuse fuses for the hybrid electric vehicle market

2012 Launches a new automotive sensor platform with the acquisition of Accel AB

2013 Expands global sensor platform in automotive market with the acquisition of Hamlin, Inc.

AEC-Q101 qualified TVS Diodes and TVS Diode Arrays

2014 Opens Technology Center to facilitate the development of next-generation products

2015 Invests in Monolith Semiconductor, a company developing silicon carbide technology for power semiconductors

2016 **Opens Silicon Valley Technology Center to accelerate the development of next-generation materials and products**

Acquires the circuit protection business of TE Connectivity, expanding presence in automotive electronics

Acquires a select portfolio of semiconductor products from ON Semiconductor

2017 Announces intent to acquire IXYS (RSS)

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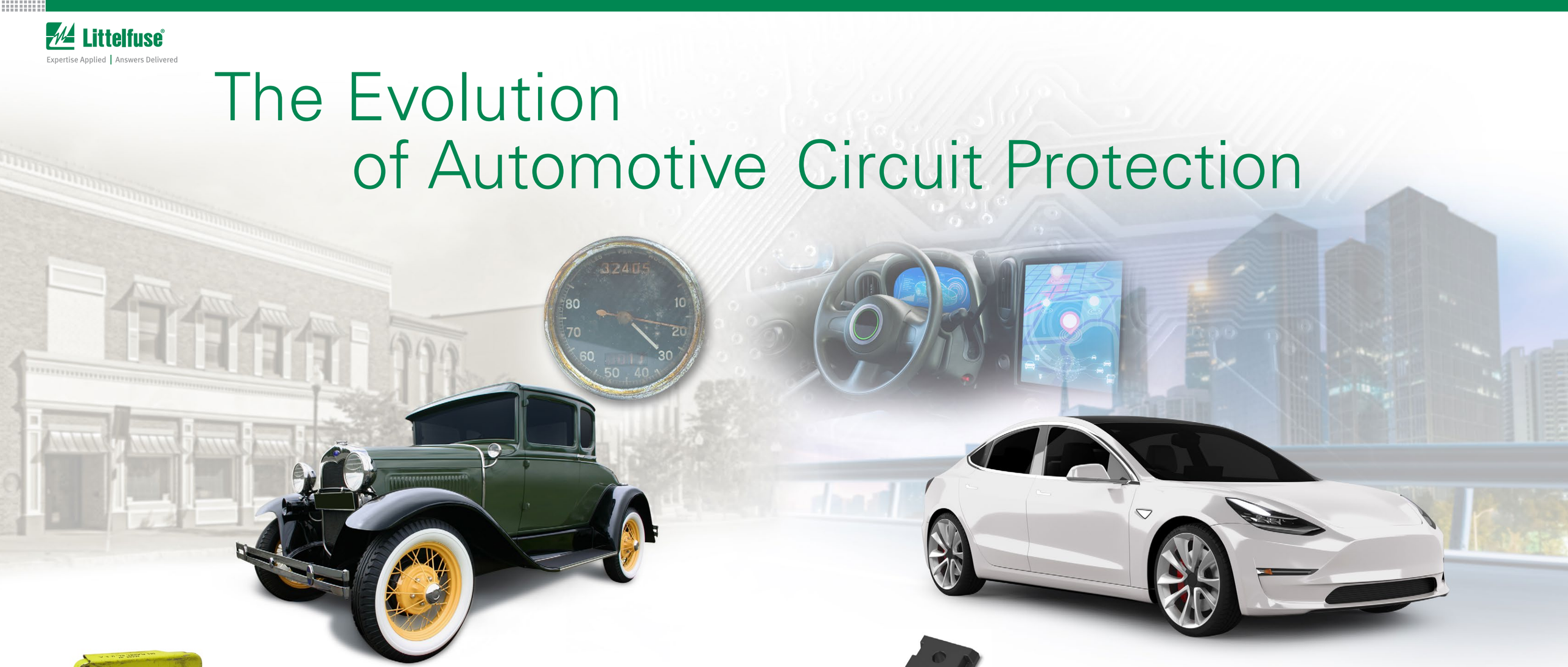
The Evolution of Automotive Circuit Protection



For many decades, vehicles were essentially mechanical systems supplemented by hydraulic or electrical systems for functions like steering, ignition, lights, and audio entertainment. Modern vehicles, unlike their predecessors, are literally stuffed with electronic systems.

ADVANCING WITH THE TIMES

With electronics controlling an ever-higher percentage of vehicle functions, the circuit protection devices that prevent hazardous overvoltages and overcurrents have evolved to keep up with the transition to what is essentially a supercomputer on wheels. In addition, electrical power control is transitioning from mechanical relays, solenoids and switches to devices like IGBTs, MOSFETs, Schottky Diodes and Thyristors.

Sophisticated electronics are now integral to vehicles sold at every price point. For example, hydraulic power steering is being superseded by steer-by-wire systems. New safety and passenger entertainment functions such as advanced driver assistance systems (ADAS), parking assist, lane departure and forward collision warning systems were once available only on high-end vehicles.

Today's cars include myriad systems that use semiconductors, and sophisticated hybrids have even more. Designers need a wide range of circuit protection options to safeguard all these new systems over the vehicle's expected 15-20-year lifetime.

DRIVING FACTORS FOR AUTOMOTIVE ELECTRONICS

A combination of powerful forces in the automotive electronics industry are spurring changes in circuit protection, power control and sensing applications.

- One wire/one fuse protection trend
- Higher power consumption
- Better space and weight efficiency
- Smarter circuit protection
- The expansion of infotainment systems
- New safety features like multiple airbags, battery disconnect controls, passenger sensing system, auto dimming mirrors, anti-rollover features, stability control, seat belt pre-tensioning and tire pressure monitoring
- Demand for higher performance and lower emissions
- The growth of hybrid, electric and alternative fuel vehicles
- Growing use of power semiconductors like Ignition IGBTs, Thyristors and Schottky Diodes

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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

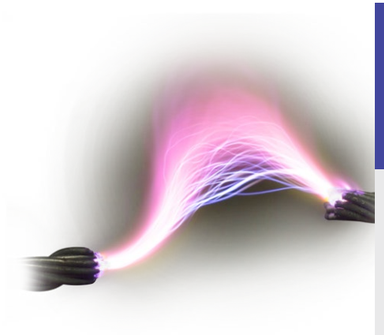
Because of their high-speed response to overvoltages, TVS Diode Arrays are widely used for ESD protection in automotive electronics. Automotive-qualified SPA® TVS Diode Arrays from Littelfuse are available in a range of compact surface-mount packages to fit into any layout.

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, so that unwanted voltage spikes or transients are generated. If left unchecked, these transients would be transmitted along the power line and into the electronic modules.

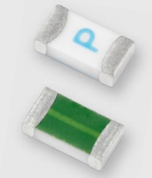
Varistors

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.



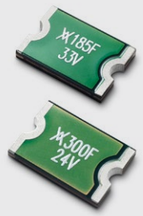
THREAT: OVERLOADS/SHORT-CIRCUIT CURRENTS

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 2022, 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 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.

Living Up to the Industry's Standards

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.

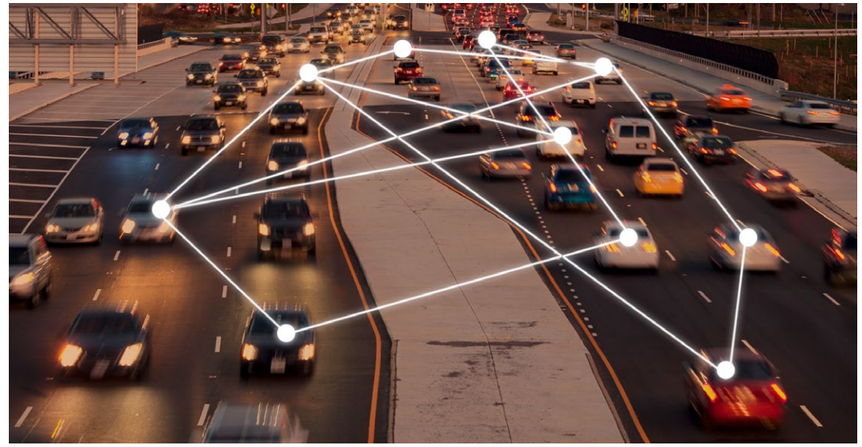
Littelfuse engineers help customers understand which standards apply in terms of both the application itself and the geographical location for which it is designed, as well as offer guidance on how to meet those standards. Littelfuse offers a broad line of circuit protection devices certified compliant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

The Future Is Now



Whether powered by gas electric, fuel cell electric, diesel electric, Li-ion polymer, or ultra-capacitor engines, electric vehicles are challenging automakers to address higher energy applications, including Battery Management Systems and on-board charging systems. Autonomous (self-driving) vehicles are already making appearances on the road. Similarly, connected vehicles are offering Internet access for connecting with devices both inside and outside the car. A range of new protocols are emerging:

- When there is the potential for a collision, V2V (vehicle-to-vehicle) communications notify the driver or autonomous vehicle to take evasive action.
- V2I (vehicle-to-infrastructure) communications allow the traffic system to collect data that can be used to control traffic light timing, allowing more efficient traffic flow.
- BroadR-Reach technology allows multiple in-vehicle systems to access information simultaneously over unshielded single twisted-pair cable.
- HDBaseT has historically been used in the consumer and high-end A/V market to provide high-bandwidth, long-reach capabilities. A new, automotive version has been introduced to provide 6Gbps throughput for in-vehicle convergence of high-def A/V, USB, ethernet, feature controls and power on a single pair of wires.

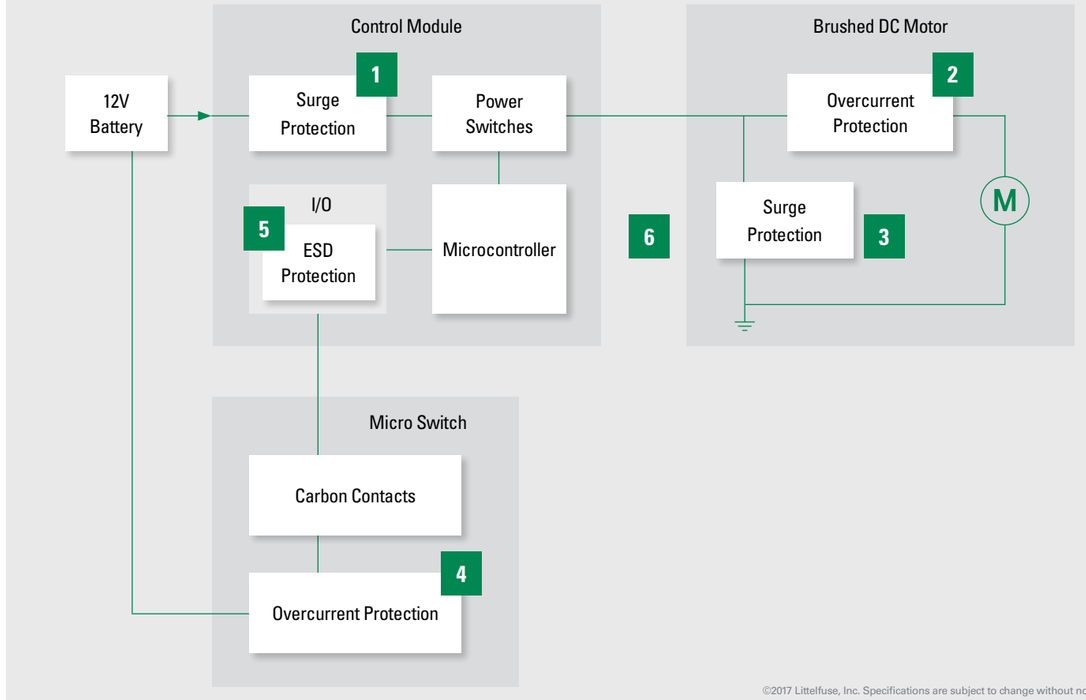
Littelfuse specialists can help designers develop automotive modules that meet the safety and test standards of the latest communication protocols.

To view this brochure in interactive format, including links to videos, selection guides and tips, information on product samples and application support, visit:
www.littelfuse.com/automotiveelectronics

Applications

MOTOR CONTROL

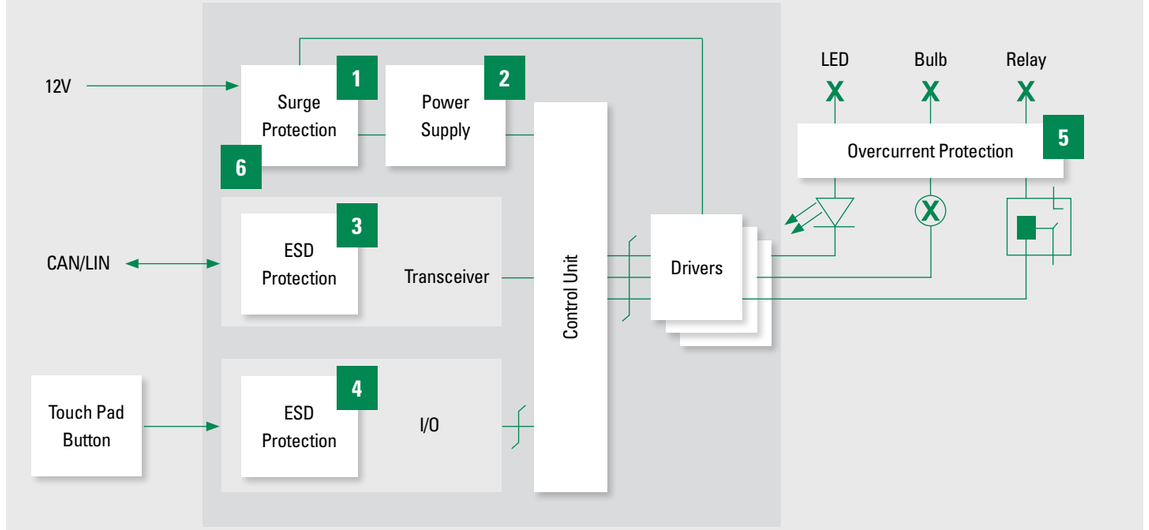
As mechanical/hydraulic actuators are replaced with electric motors, such as those for electric parking, braking, seat modules and mirrors, motor control circuit protection is critical to a vehicle's overall reliability. Potential threats include load dump, overcurrents, surges and ESD. Littelfuse offers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



	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
2	**Overcurrent Protection**	PPTC	TD, CHIP, Rline	Normally custom made to fit into the motor housing. By mounting them close to the motor windings, they will trip more quickly when the motor windings are hot and therefore closer to being damaged, and more slowly when the motor windings are cold.
3	**Overvoltage Protection**	Metal Oxide Varistor (MOV)	AUMOV	Radial-leaded MOV with up to 10kA surge current and 2.5kV isolation voltage capability up to 125°C
4	**Overcurrent Protection**	SMD PPTC	miniASMD	Resettable SMD overcurrent protection up to 3A
5	**ESD Protection**	Diode Array	AQ1, MLA Auto	Industry-standard solution for ESD protection up to 3A
6	**Overvoltage Protection**	TVS Diode	TPSMB, TP6KE	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W

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.

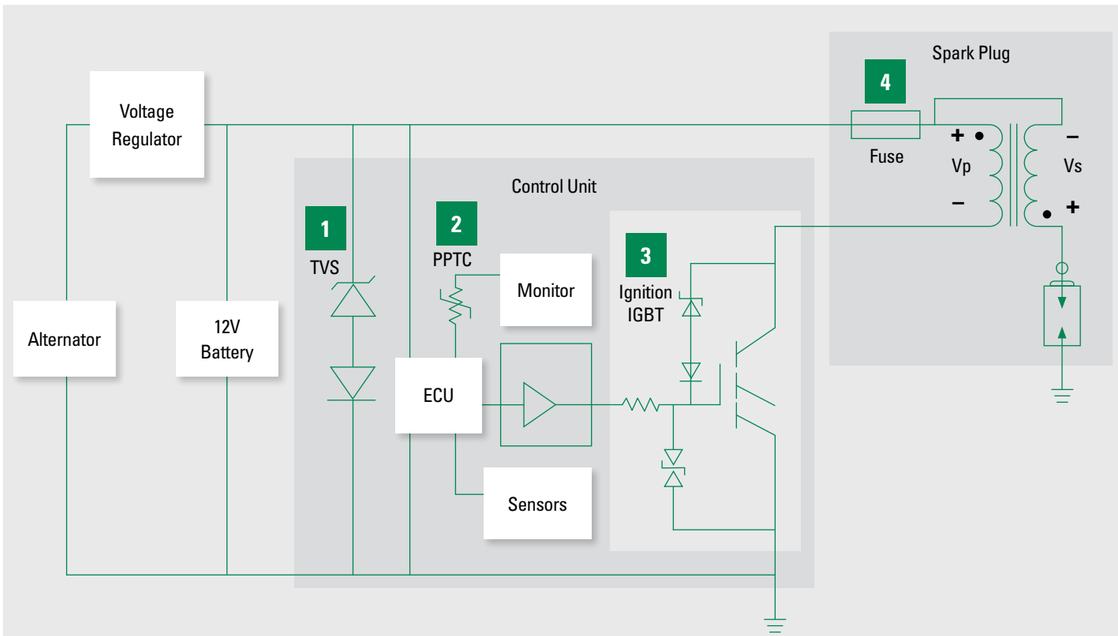


	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
2	**Reverse Blocking/ Output Rectification**	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A
3	**CAN Bus ESD Protection**	TVS Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus
	LIN Bus ESD Protection	TVS Diode Array	AQ24C	Industry-standard solution for ESD and surge protection for LIN bus
4	**IO Protection**	TVS Diode Array	AQ1	General-purpose ESD Diodes in multiple package options and ESD capability of 30kV
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
5	**Thermal Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
6	**Reverse Polarity Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

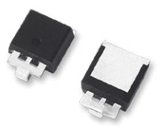
Applications

IGNITION SYSTEM

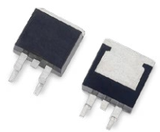
The efficiency of gasoline engines and consequently their mileage and emissions, are dependent on the performance of the ignition system. The latter must be protected against variety of threats, including load dumps, feedback loops and overcurrents. In addition to high-performance Ignition IGBTs, Littelfuse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



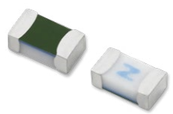
	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer varistor with load dump energy rating per SAE Specification J1113
2	**Feedback Loop Protection**	PPTC	miniASMD	Resettable SMD overcurrent protection up to 2.6A
3	**Ignition**	IGBT	NGB, NGD	Ignition IGBTs with integrated ESD and overvoltage clamping protection above 350 Vbr
4	**Coil Overcurrent Protection**	SMD Fuse	440A, 441A	High I^2t SMD fuse in 1206 package for applications up to 0.75 A/63 Vdc and 8 A/32 Vdc



SLD8 TVS Diode Array



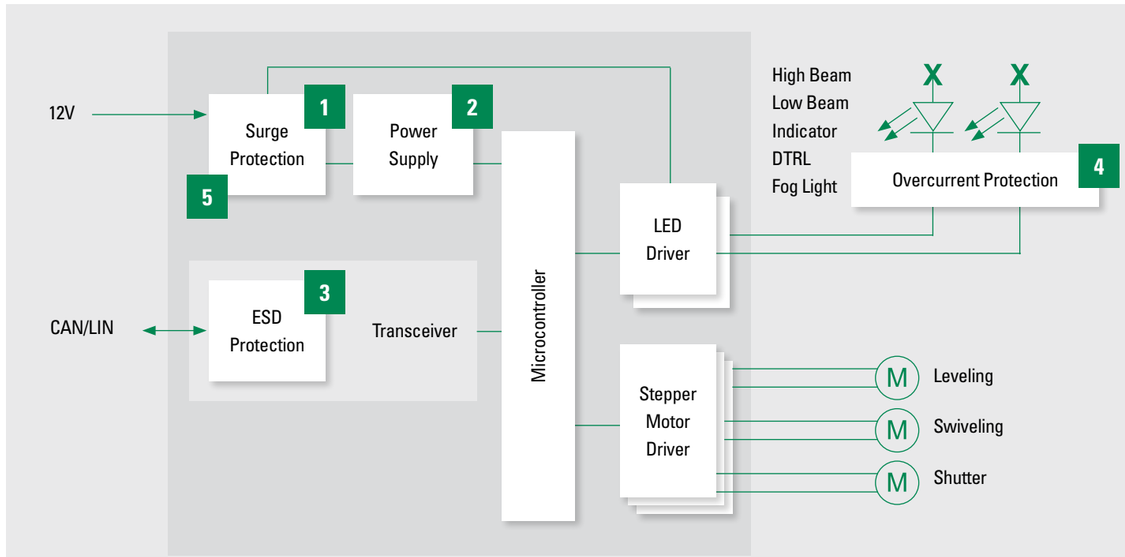
NGB IGBT



441A SMD Fuse

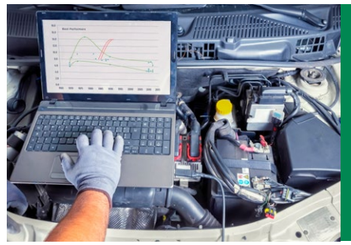
LIGHTING – HEADLAMPS

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.



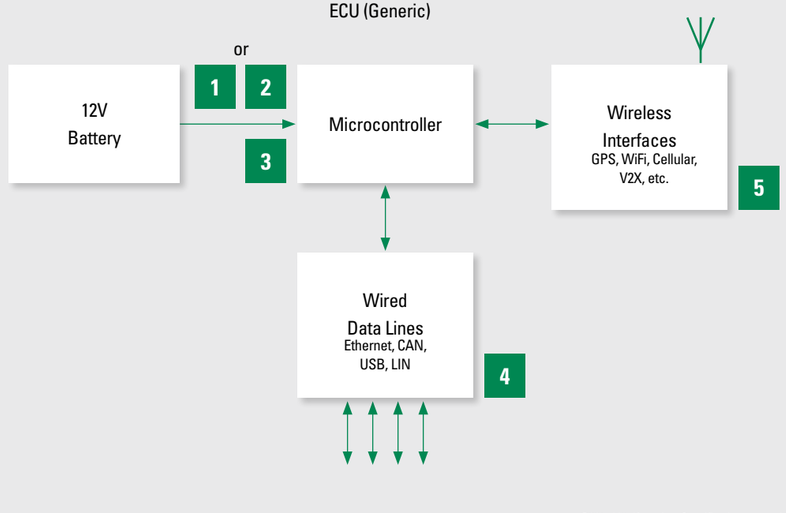
	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
2	**Freewheeling Diode**	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop
3	**CAN Bus ESD Protection**	TVS Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus
	LIN Bus ESD Protection	TVS Diode Array	AQ24C	Industry-standard solution for ESD and surge protection for LIN bus
4	**Short Circuit Protection**	SMD Fuse	501A	High I^2t SMD Fuse with ratings up to 32V and 20A
5	**Reverse Polarity Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

Applications



ECU

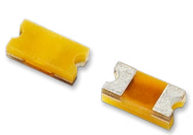
Various Electronic Control Units (ECUs) are used for functions such as engine control, GPS connectivity, transmission control, door lock and eCall. They have interfaces like power input and communication. Defense against overcurrents, surges and ESD requires a range of circuit protection devices such as Fuses, PPTCs, TVS Diodes and Diode Arrays, MOVs, MLVs and Polymer ESD Suppressors.



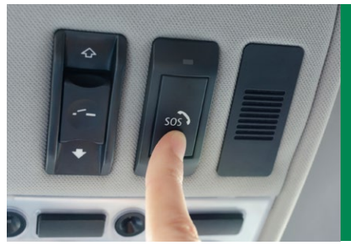
	Function	Product Family	Product Series	Product Description
1	Overcurrent Protection	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection up to 63V and 3.5A
2	Overcurrent Protection	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
3	Overvoltage Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Metal Oxide Varistor (MOV)	AUML	Multilayer Varistor with load dump energy rating per SAE Specification J1113
4	ESD/Surge Protection	TVS Diode Array	AQ1, AQ3	AQ1 Series ESD Diodes are used for slow-speed interfaces, and AQ3 Series ESD Diodes are used for high-speed interfaces
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
5	ESD Protection	XTREME-GUARD™	AXGD	Protection of sensitive electronics against electrostatic discharges up to 30kV while adding virtually no capacitance to the circuit, which helps preserve signal integrity and minimize data loss

TPSMD Diode

MLA Auto Multilayer Varistor

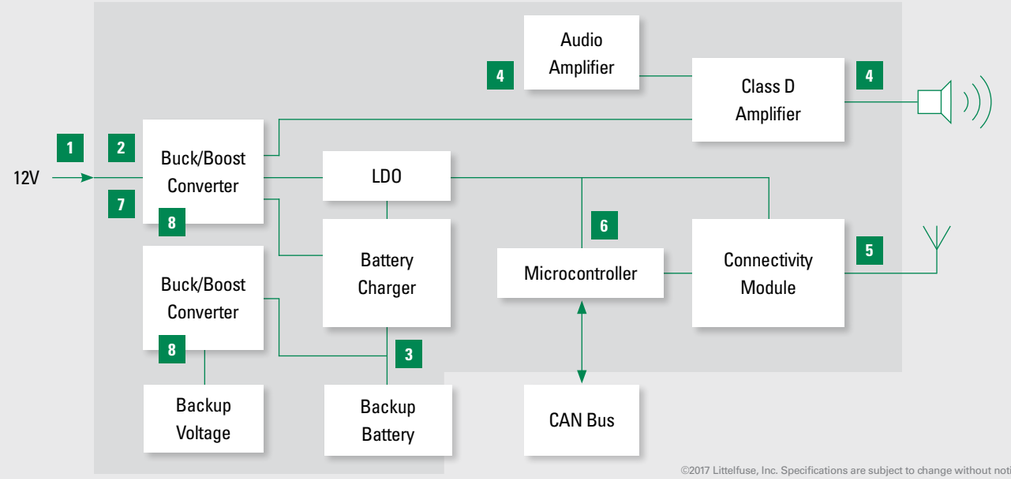


XTREME-GUARD™ ESD Suppressor



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.

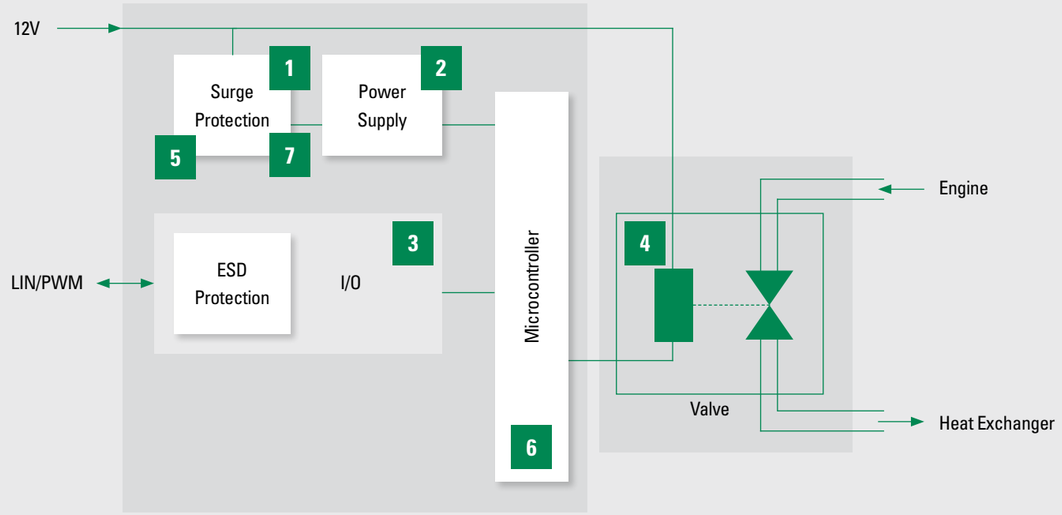


	Function	Product Family	Product Series	Product Description
1	Load Dump Protection	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
2	Overcurrent Protection	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection; tested to ensure compatibility with automotive applications
3	Overcurrent Protection	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A
4	Overvoltage Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Metal Oxide Varistor (MOV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
5	ESD Protection	XTREME-GUARD™	AXGD	Protection of sensitive electronics against electrostatic discharges up to 30kV while adding virtually no capacitance to the circuit, which helps preserve signal integrity and minimize data loss
6	ESD Protection	Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus
7	Reverse Polarity Protection	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A
8	Reverse Blocking/ Output Rectification	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

Applications

ENGINE COOLING SYSTEM

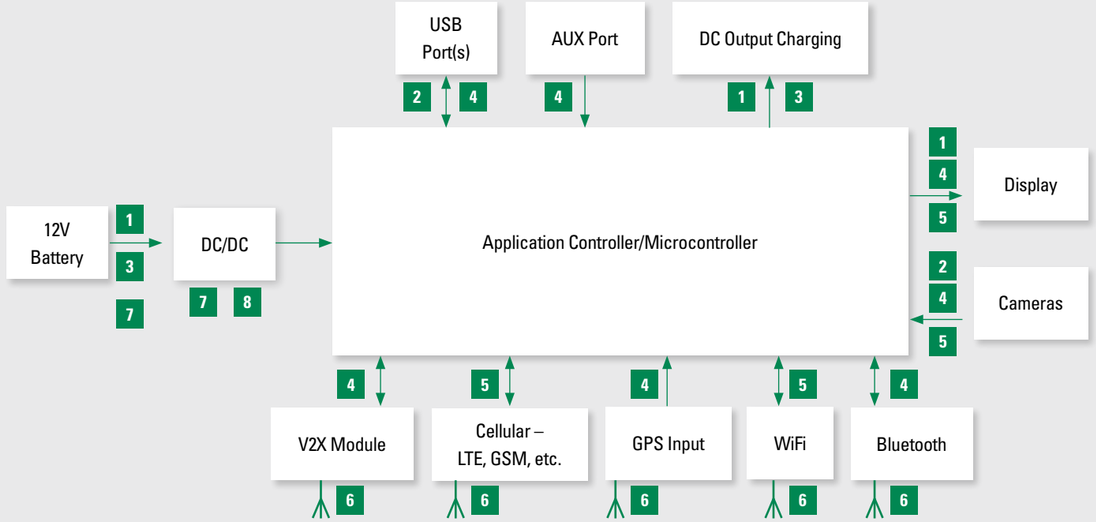
Engines depend on a steady flow of cooling fluid to maintain optimal performance. Engine cooling systems need protection against threats such as load dump, surges, ESDs and overheating. The growing range of Littelfuse solutions includes TVS Diodes and Diode Arrays, MLVs, MOVs, Schottky Diodes and SMD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



	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
2	**Reverse Blocking/ Output Rectification**	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop
3	**PWM (IO) Protection**	TVS Diode Array	AQ1	General purpose ESD Diodes in multiple package options and ESD capability of 30kV
	LIN Bus ESD Protection	TVS Diode Array	AQ24C	Industry-standard solution for ESD and surge protection for LIN bus
4	**Switching Element Protection**	Metal Oxide Varistor (MOV)	AUMOV	Radial-leaded MOV with up to 10kA surge current and 2.5kV isolation voltage capability up to 125°C
5	**Reverse Polarity Protection**	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A
6	**Standard Surge Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
7	**Reverse Polarity Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

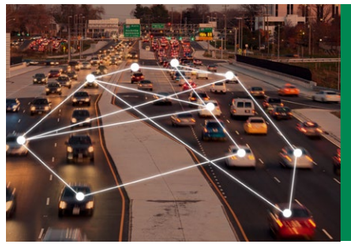
INFOTAINMENT AND NAVIGATION

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 protection solutions, including SMD Fuses, SMD PPTCs, TVS Diodes and Diode Arrays, MLVs and XTREME-GUARD™ ESD Suppressors.



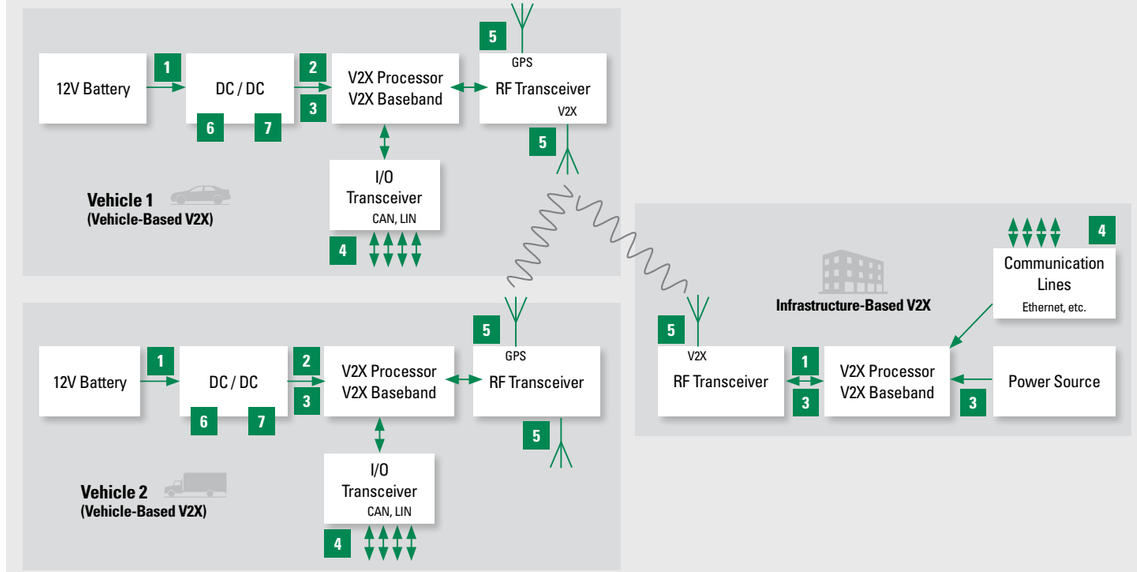
	Function	Product Family	Product Series	Product Description
1	**Overcurrent Protection**	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection up to 63V and 3.5A
2	**Overcurrent Protection**	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A
3	**Overvoltage Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
4	**ESD/Surge Protection**	TVS Diode Array	AQ1	Uni- and bi-directional ESD protection Diode with 30pF and 30kV ESD capability
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppression Varistor up to 120Vdc and 8/15kV ESD capability
5	**ESD Protection**	TVS Diode Array	AQ3	Protection of high-speed digital data lines. Discrete and array options for low capacitance available.
6	**ESD Protection**	XTREME-GUARD™	AXGD, SESD	Protection of sensitive electronics against electrostatic discharges up to 30kV while adding virtually no capacitance to the circuit, which helps preserve signal integrity and minimize data loss
7	**Reverse Polarity Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A
8	**Reverse Blocking/ Output Rectification**	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

Applications



VEHICLE COMMUNICATION

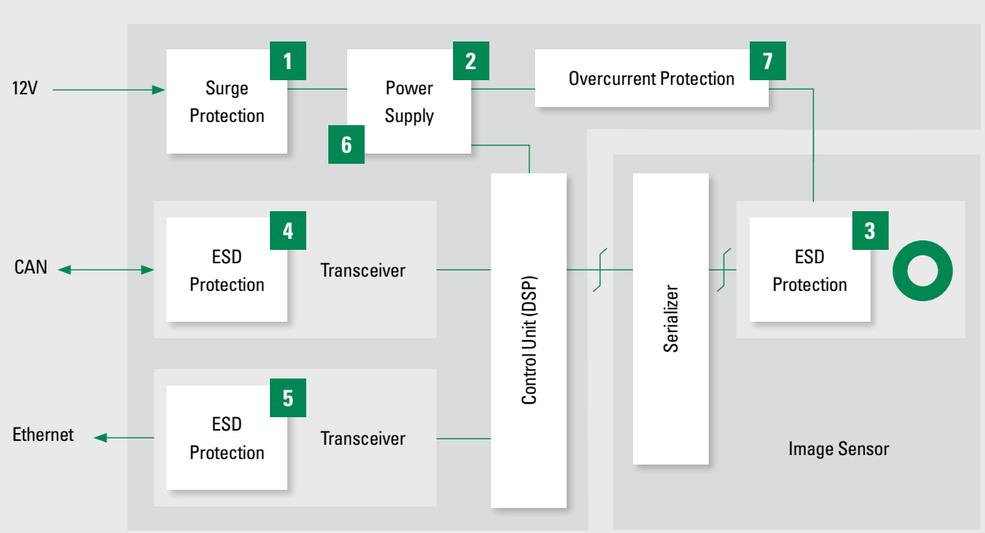
V2V and V2I will provide new levels of safety and efficiency by sharing data on vehicle locations and speed/direction, as well as receiving information from smart traffic signals. On-board power and communication circuits in these systems need overcurrent, ESD and surge protection using Fuses, PPTCs,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



	Function	Product Family	Product Series	Product Description
1	**Overcurrent Protection**	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection up to 63V and 3.5A
2	**Overcurrent Protection**	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A
3	**Overvoltage Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
4	**ESD/Surge Protection**	TVS Diode Array	AQ1, AQ3, SM24CAN, AQxx	Broad selection of robust ESD Diodes to protect general-purpose, high-speed and legacy automotive communication buses
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
5	**ESD Protection**	XTREME-GUARD™	AXGD	Protection of sensitive electronics against electrostatic discharges up to 30kV while adding virtually no capacitance to the circuit, which helps preserve signal integrity and minimize data loss
6	**Standard Surge Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
7	**Reverse Polarity Protection**	SMD PPTC	miniASMD, ASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A

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.

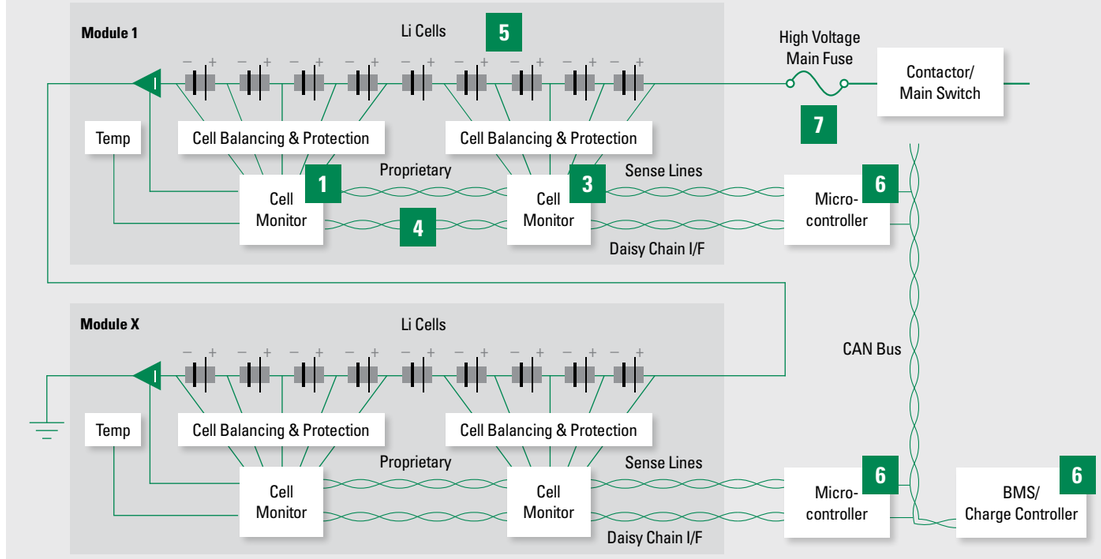


	Function	Product Family	Product Series	Product Description
1	**Load Dump Protection**	TVS Diode	SLD8	TVS Diode for ISO7637-2 5a/5b and ISO16750 load dump protection with peak pulse capability of 7000W
		Multilayer Varistor (MLV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
	Standard Surge Protection	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
2	**Reverse Blocking/ Output Rectification**	Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop
3	**High Speed ESD Protection**	TVS Diode Array	AQ3, SESD	Uni- and bi-directional ESD protection Diode with 0.5pF and 3/5A peak current capability
4	**CAN Bus ESD Protection**	TVS Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus
5	**Ethernet Protection**	TVS Diode Array	AQ3, SESD	Low-capacitance ESD Diodes are used in high-speed interfaces, to ensure ESD protection and signal integrity
6	**Reverse Polarity Protection**	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A
		Schottky Diode	DST	Ultra-Low V_F Schottky Barrier Rectifier meets the general requirements of automotive applications by providing high temperature capability, low leakage and low forward voltage drop to 100V and 10A
7	**Short Circuit Protection**	SMD PPTC	ASMD, miniASMD	Resettable SMD overcurrent protection up to 3A

Applications

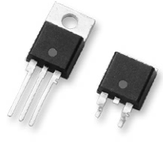
BATTERY MANAGEMENT SYSTEM

The Battery Management System (BMS) maintains the safe operation of the high voltage battery and can relay information about the battery to power and energy management systems. The BMS requires protection from threats such as overcurrents, surges and ESD. Fuses, TVS Diodes and Diode Arrays keep this system reliable and safe under all conditions (assembly, maintenance and normal operation).



	Function	Product Family	Product Series	Product Description
1	**Overcurrent Protection**	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection up to 63V and 3.5A
2	**Overcurrent Protection**	Fuse in Wiring Harness	Cartridge	Ceramic fuse 15–30A with 10kA interrupt rating up to 450Vdc
3	**Overvoltage Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
4	**ESD Protection**	Diode Array	AQ1	Uni- and bi-directional ESD protection Diode with 30pF and 30/30kV ESD capability
5	**Overvoltage Protection**	TVS Diode	TPSMC	Designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events
6	**ESD Protection**	Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus
7	**Main High-Voltage Battery Fuse**	High Voltage Fuse	20EV, 30EV	High-current xEV Fuse with ratings 60–250A and up to 500Vdc

AUMOV Varistor

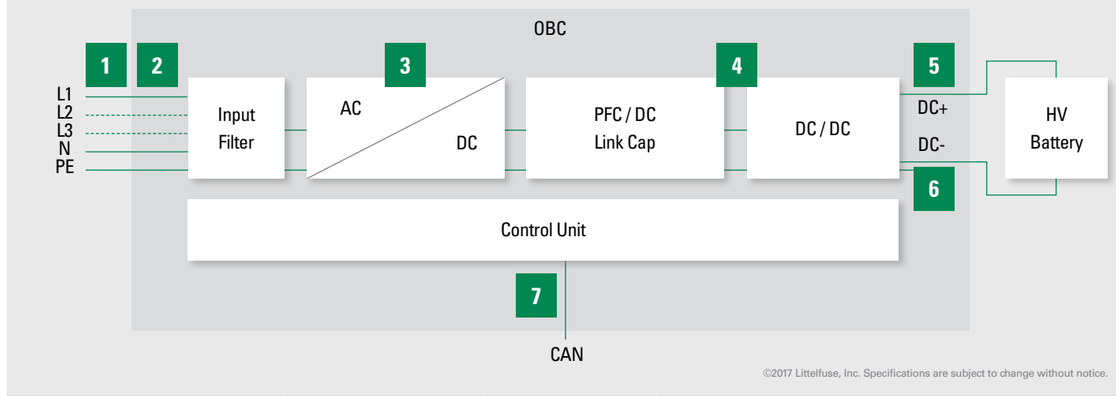


S8016xA Switching Thyristor

HEV High Voltage Fuse

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, overvoltages 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.

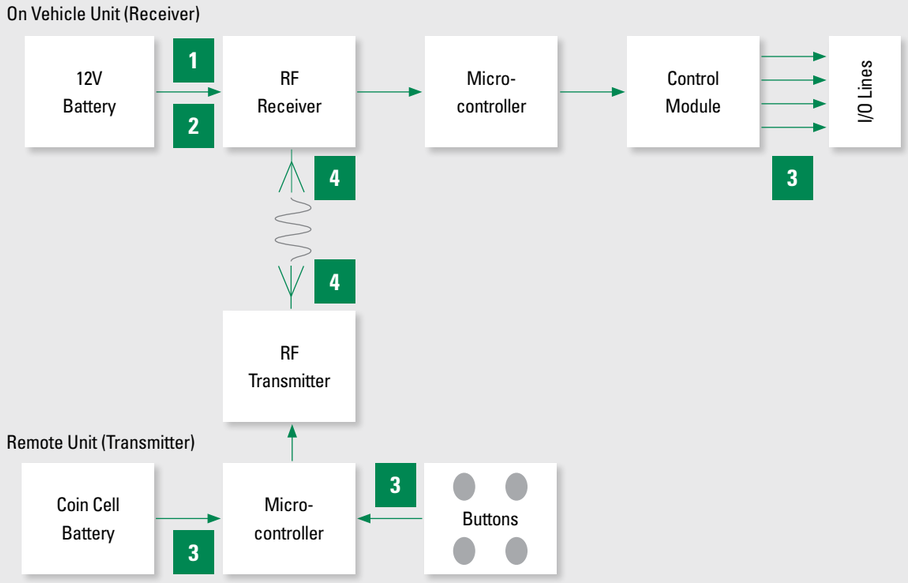


	Function	Product Family	Product Series	Product Description
1	**Overcurrent Protection**	High Voltage Fuse	OHEV, 10EV	Low current Fuse with ratings 10-50A and 500Vdc and with different mounting options
			20EV	High-current xEV Fuse with ratings 60-125A and up to 500Vdc
2	**Overvoltage Protection**	Varistor + GDT (Gas Discharge Tube)	AUMOV, CG2/3	A combination of Varistors and Gas Discharge Tubes limits transient overvoltages from indirect lightning up to 20kA impulse discharge current
		TVS Diode	30KPA-HR	Designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events
3	**Rectification**	Switching Thyristor	S8016xA	Specifically designed for electric vehicle on-board charger applications. Its excellent AC handling capability and surge robustness makes this series an ideal switch for these input rectifiers
4	**Overvoltage Protection**	TVS Diode	TPSMB	Designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events
5	**Overcurrent Protection**	High Voltage Fuse	OHEV, 10EV	Low current Fuse with ratings 10-50A and 500Vdc and with different mounting options
			20EV	High-current xEV Fuse with ratings 60-125A and up to 500Vdc
6	**Overvoltage Protection**	TVS Diode	TPSMB	Designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events
7	**ESD Protection**	Diode Array	SM24CAN	Industry-standard solution for ESD protection on CAN bus

Applications

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.



	Function	Product Family	Product Series	Product Description
1	**Overcurrent Protection**	SMD Fuse	437A, 440A, 441A	SMD Fuses for overcurrent protection up to 63V and 3.5A
2	**Overvoltage Protection**	TVS Diode	TPSMA, TPSMB, TPSMC, TPSMD	TVS Diode for secondary induced transient voltages with peak pulse capability from 400W to 5000W
		Metal Oxide Varistor (MOV)	AUML	Multilayer Varistor with load dump energy rating per SAE specification J1113
3	**ESD/Surge Protection**	TVS Diode Array	AQ1	General purpose ESD Diodes in multiple package options and ESD capability of 30kV
		Multilayer Varistor (MLV)	MLA Auto	Voltage suppresion Varistor up to 120Vdc and 8/15kV ESD capability
4	**ESD Protection**	XTREME-GUARD™	AXGD	Surface-mount solution for ESD and induced surge energy

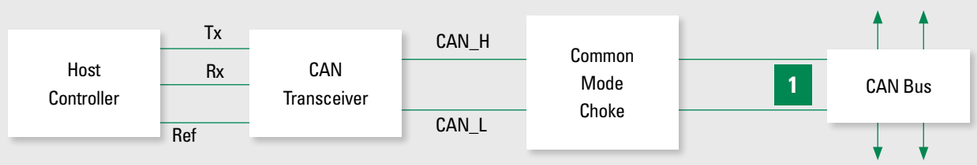
SM24CAN TVS Diode Array

SD24C TVS Diode Array

TPSMA TVS Diode

COMMUNICATION SYSTEMS - CAN BUS

The CAN bus provides command and control functions through a reliable, fault-tolerant sensitive interface. Typical applications include engine control, transmission control, anti-lock braking and other mission-critical systems. ESD and induced surges are the most common threats facing CAN bus systems. Littelfuse TVS Diode Arrays are specifically designed to protect sensitive I/O interfaces.

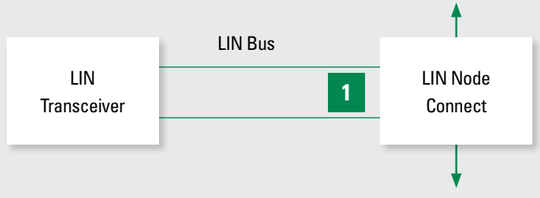


	Function	Product Family	Product Series	Product Description
1	**ESD/Surge Protection**	Diode Array	AQ24C	Industry-standard solution for ESD and surge protection for CAN bus

COMMUNICATION SYSTEMS - LIN BUS

The LIN bus is typically used for body control functions for applications such as power windows, seat controllers, sun roofs and trunk latches. ESD and induced surges are the most common threats. Littelfuse TVS Diode Arrays are specifically designed to protect sensitive I/O interfaces.

LOCAL INTERCONNECT NETWORK



	Function	Product Family	Product Series	Product Description
1	**ESD/Surge Protection**	Diode Array	AQ24C	Industry-standard solution for ESD and surge protection for LIN bus

Littelfuse®

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