



Expertise Applied | Answers Delivered

xEV power train



Automotive

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 the fitness of 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: www.littelfuse.com/disclaimer-electronics.

Advanced electronics are driving 80% of the innovation in multiple automotive applications

In-vehicle infotainment & communication

- Smart infotainment
- Navigation
- Multipurpose camera
- Telematics box



Network systems & body electronics

- CAN, LIN
- USB, Wireless
- Keyless entry
- Lighting control



Advanced driver assistance system

- V2X Communication
- Radar
- eCall
- Sensor fusion



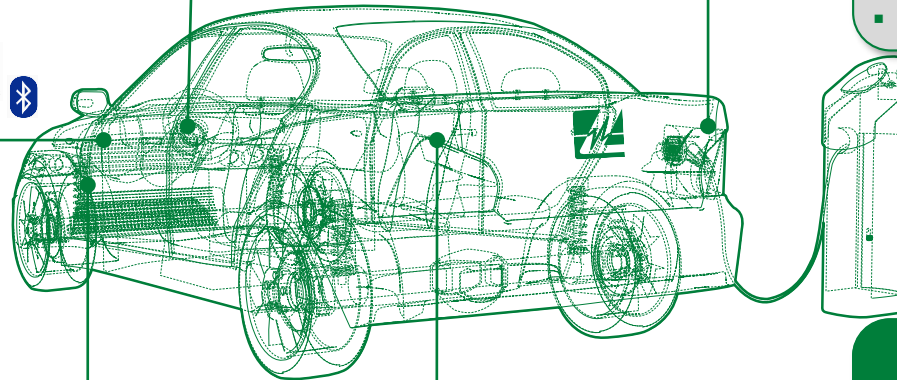
xEV (Hybrid/Battery electric) & power train

- Battery management system
- On-board charger
- Traction motor inverter
- DC/DC converter



Chassis & safety system

- Seatbelt safety
- Tire pressure monitoring
- Battery disconnect
- Fuel level detection



Increased need for circuit protection, power control and sensing products to ensure safety and reliability



xEV market key takeaways

Market Trends

Global sales of passenger cars were sluggish in 2019, but electric cars had another banner year. The global electric car fleet was 7.2 million (2019) versus 5.1 million (2018). By 2030, global EV sales will reach 25 million units. China will continue to dominate the EV market

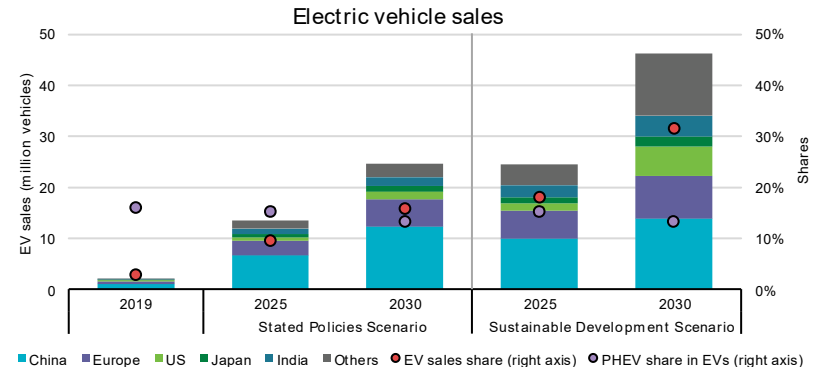
The infrastructure for electric-vehicle charging continues to expand. There were 7.3 million chargers worldwide in 2019 (6.5 million were private). Convenience, cost-effectiveness and a variety of support policies (such as preferential rates, equipment purchase incentives and rebates) are the main drivers

Electric car sales drive cost reductions in batteries, which boosts deployment across all road vehicle categories

Policies continue to support electric vehicle deployment and are evolving to a more holistic policy portfolio. Environmental and sustainability objectives drive electric vehicle policy support at all governance levels

Market Projections

Source: [Global EV Outlook 2020](#)

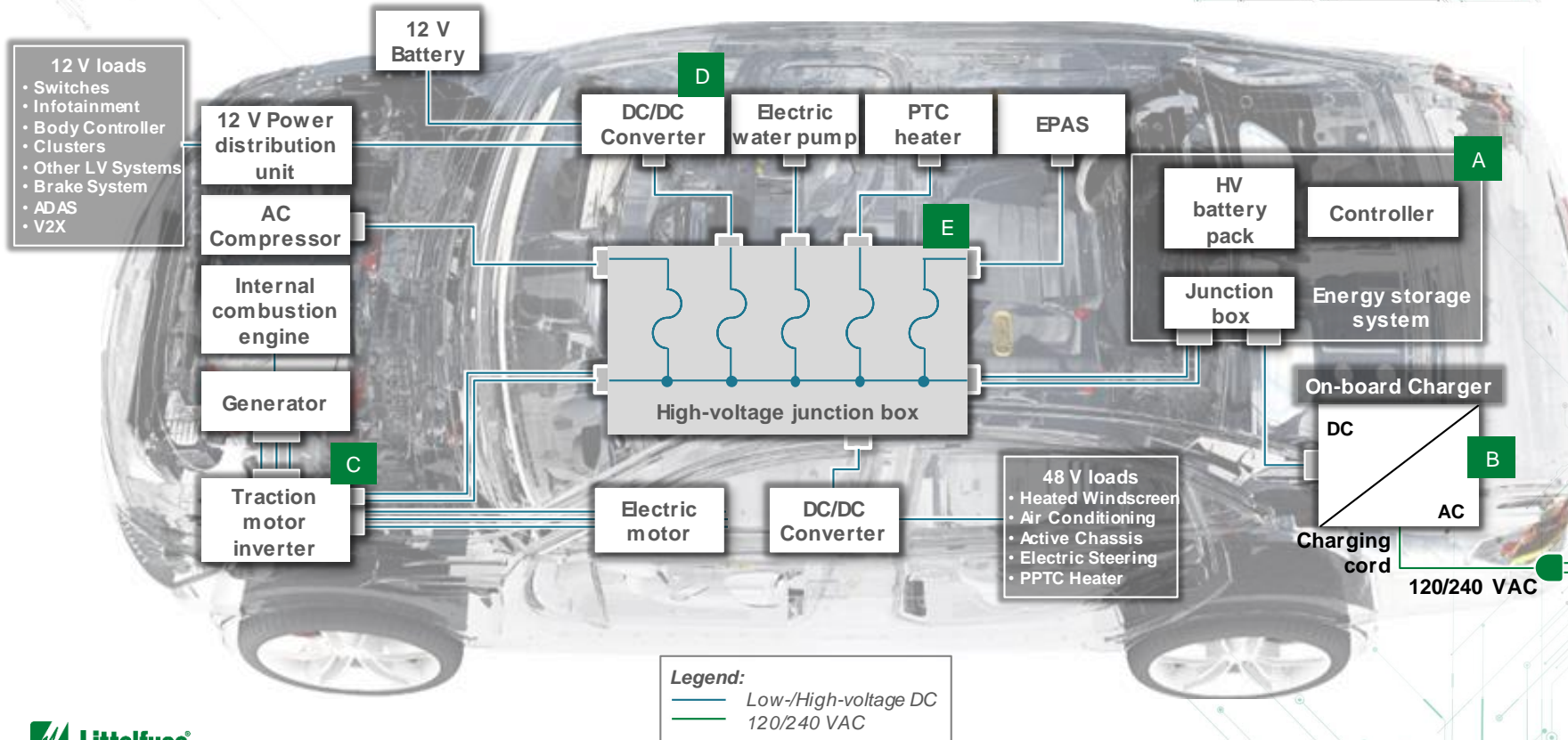


Stated Policy Scenario includes aims to illustrate the likely consequences of existing and announced policy measures.

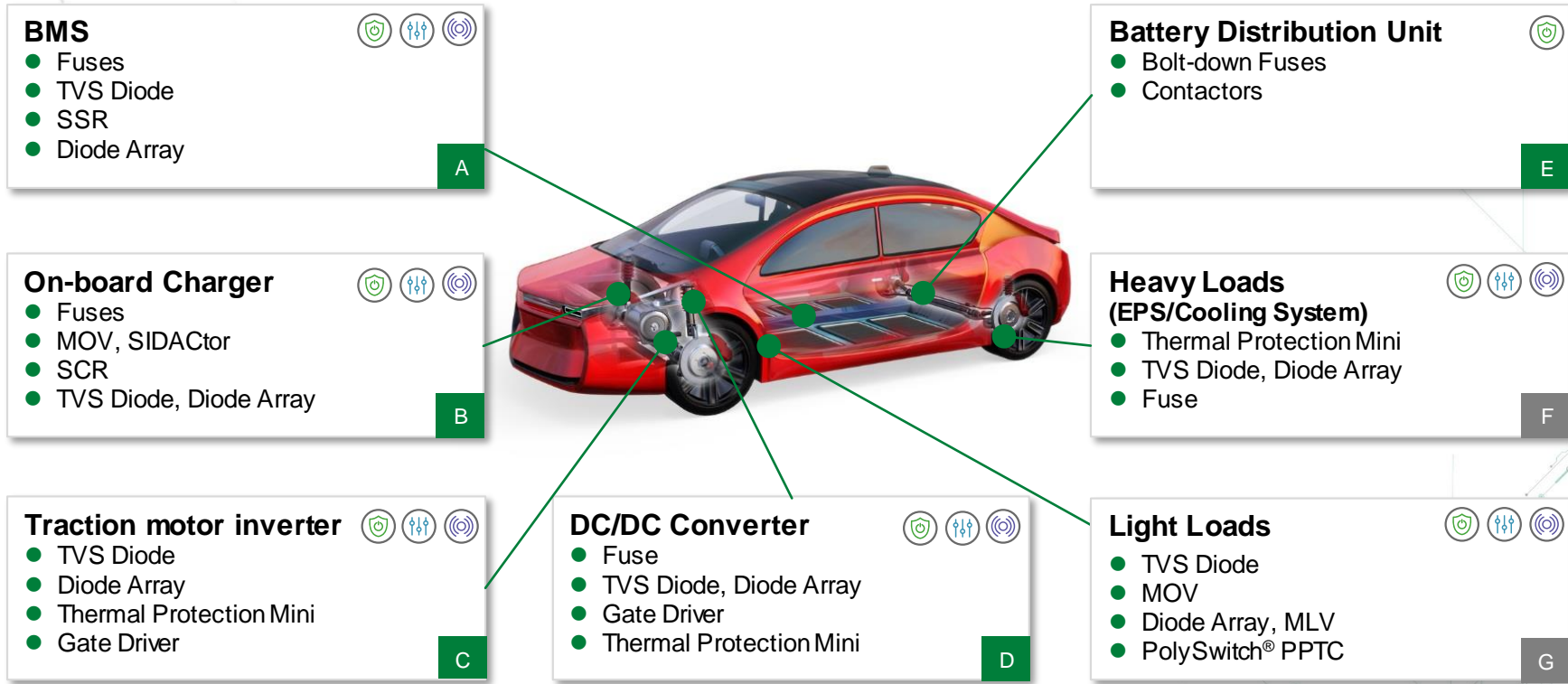
Sustainable Development Scenario aims at ensuring universal energy access for all by 2030, bringing about sharp reductions in emissions of air pollutants and meeting global climate goals in line with the Paris Agreement. It is based on limiting the global temperature rise to below 1.7–1.8 degrees Celsius with a 66% probability, reaching net zero emissions by 2070

Government regulations, environmental concerns and performance drive shift to EV

Overview of the powertrain for electric vehicle

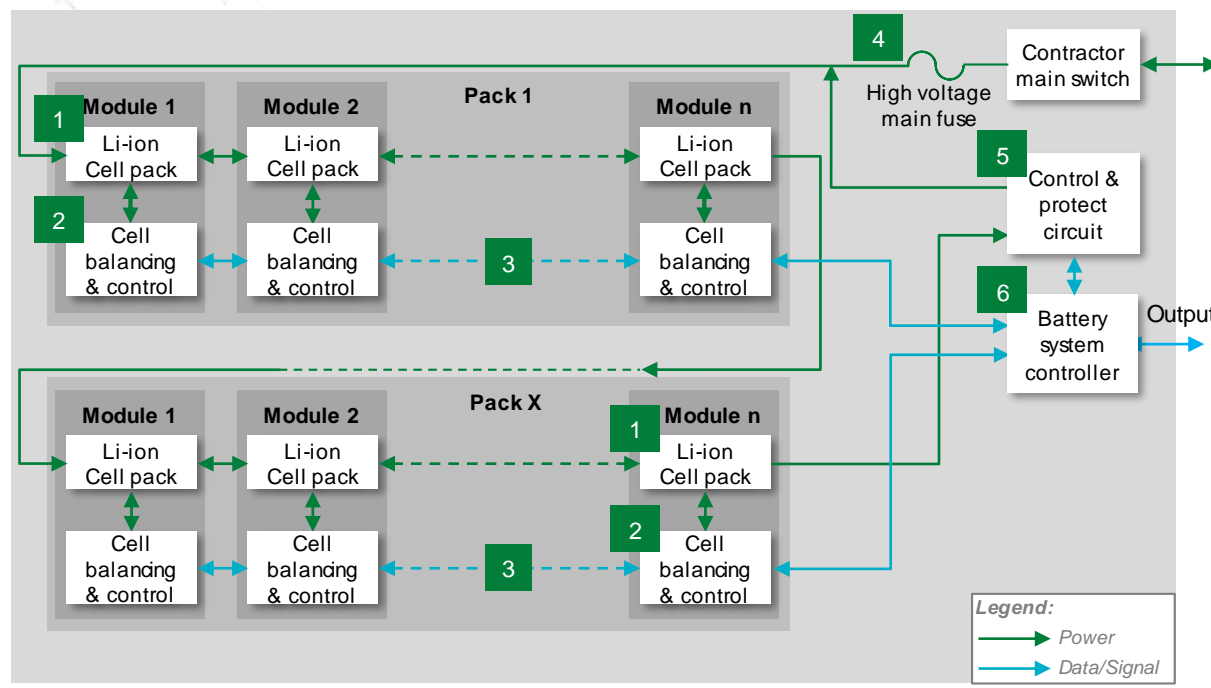


Electric vehicles (passenger & commercial) share many functional blocks including common powertrain architectures



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

Energy storage system block diagram



	Technology	Product Series
1	SMD Fuse	501A, 881A
	TVS Diode	TPSMC, SZ1SMC, SZ1.5SMC
2	SMD or In-line Fuse	438A, 441A, 521
	TVS Diode	TPSMB, SZ1SMB, SZP6SMB
3	Diode Array	AQ05C
	TVS Diode	TPSMA6L, SZ1SMA
4	High-voltage fuse	SHEV, 20HEV
5	Gate Driver	JXD_6xxSI
6	Diode Array	AQ24CANA
	Fuse	885
	TVS Diode	TPSMB, TPSMC

Acronyms:
 MOV: metal oxide varistor
 TVS: transient voltage suppressor
 SMD: surface mount device



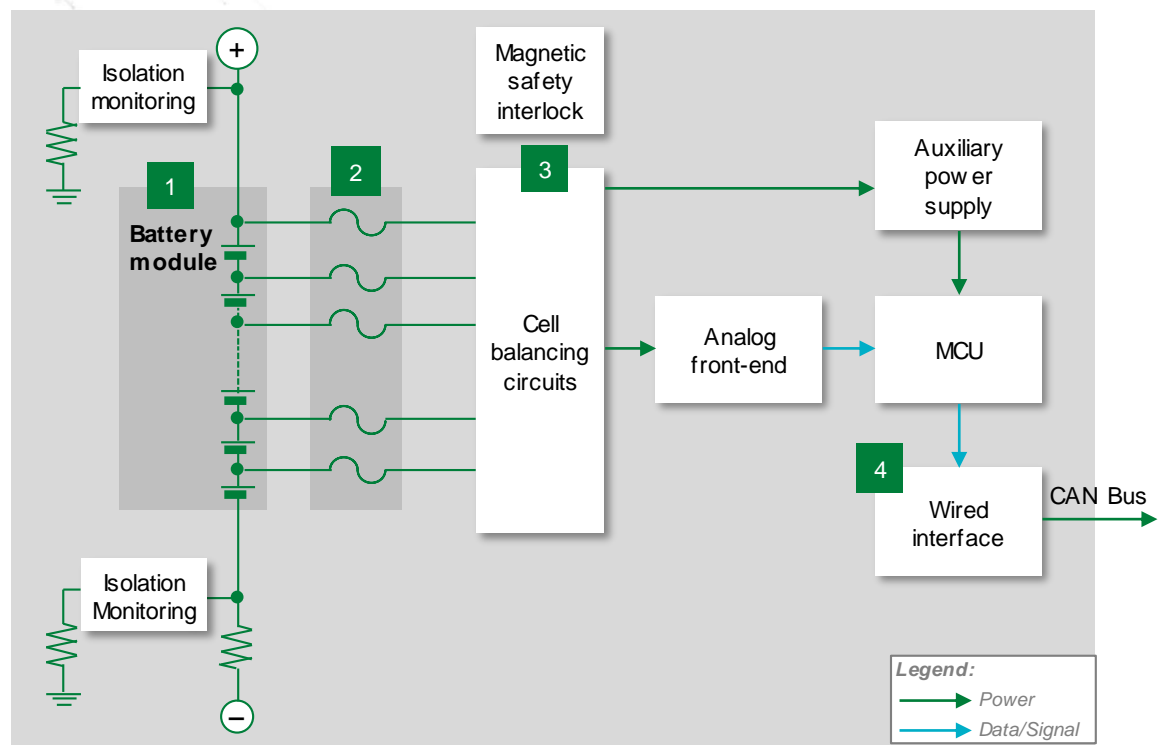
Click on the product series in the table below for more info

Potential Littelfuse products for cell/module level protection

	Technology	Function in application	Series	Benefits	Features
1	SMD Fuse	Protects cells and downstream BMS components from high fault currents due to external shorts	501A , 881A	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	TVS Diode	Transient Voltage Suppression	TPSMC , SZ1SMC , SZ1.5SMC	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
2	SMD or In-line Fuse	Protect cells and BMS components from overcurrent	438A , 441A , 521	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	TVS Diode	Transient Voltage Suppression	TPSMB , SZ1SMB , SZP6SMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
3	TVS Diode	Transient Voltage Suppression	AQ05C	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	TVS Diode Array	Protects sensitive electronic ICs from ESD, EFT and voltage transient	TPSMA6L , SZ1SMA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
4	High-voltage Fuse	Short Circuit Protection Overload Circuit Protection	SHEV , 20HEV	Provides safety protection in high-voltage environments, full range fuse	Bolt down form factor, high breaking capacity, qualified to ISO 8820 standard
5	Gate Driver	Controls the switching MOSFETs	IXD_6xxSI	Dual outputs provide space efficient design, high immunity to latch-up, rise/fall times less than 10 ns	Tight tolerance, small form factor, fast thermal response.
6	Diode Array	Protect CAN bus from ESD, EFT and voltage transient	AQ24CANA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
	SMD Fuse	Protects cells and BMS components from over current	885	High voltage SMD form-factor allows for compact design, ceramic body ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	TVS diode	Transient Voltage Suppression	TPSMB , TPSMC	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges

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

Battery module block diagram



	Technology	Series
1	HV Fuse	885 , 521
2	LV Fuse	440A , 437A , 438A
3	TVS Diode	TPSMB , SZ1SMB
4	Diode Array	AQ24CANA

Acronyms:
 HV: high voltage
 LV: low voltage

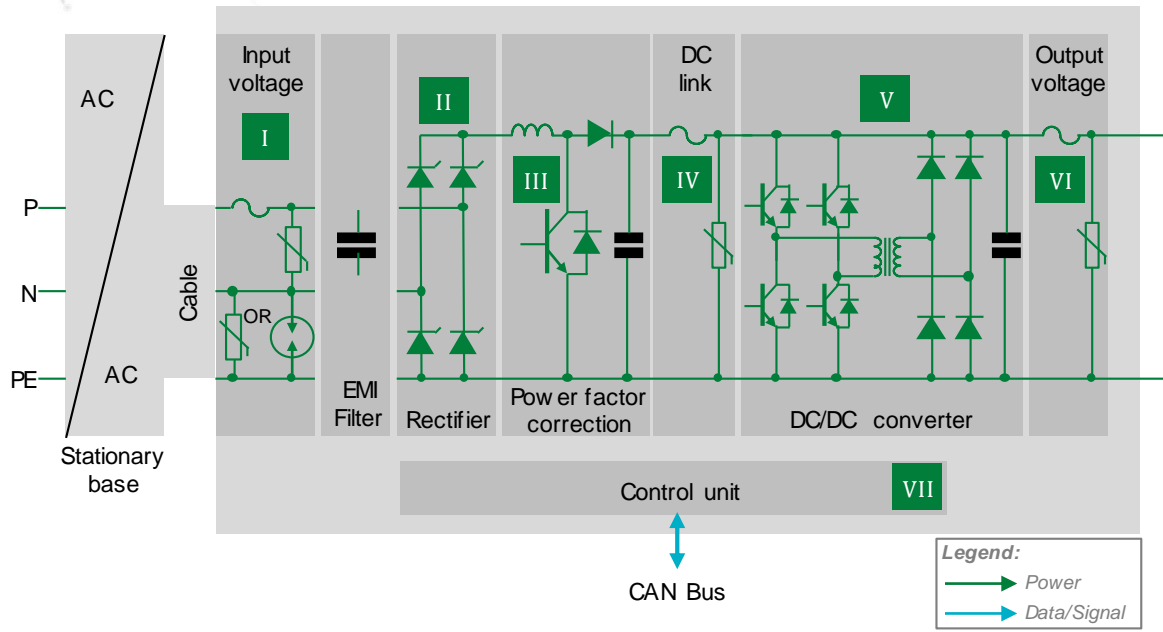


Protection and sensing solutions for battery packs

	Technology	Function in application	Series	Benefits	Features
1	HV Fuse	Protect battery pack module and cable from over current	885 , 521	Reduces customer qualification time by complying with Third party safety standards such as ISO	Third party compliance UL#ISO; low internal resistance; shock safe; vibration resistant
2	LV Fuse	Analog front-end protection of user and environment in case of external short, overload between power-sense line	440A , 437A , 438A	AEC-Q compliant based on inhouse test, reduces customer qualification time by complying with third party safety standards such as UL/IEC; SMD form-factor allows for compact design	Surface mountable; compatible with lead-free solder process per IEC standards; high reliability
3	TVS Diode	Protect sensitive electronic components from voltage transients	TPSMB , SZ1SMB	Improves system reliability by protecting downstream components from transients on power lines	600 W peak pulse capability; compatible with lead-free solder reflow temperature profile
4	Diode Array	Protect can bus sensitive electronic ICs from ESD, EFT and voltage transient	AQ24CANA	Smaller form-factor and multi-line protection enable ease of design	AECQ-101 qualified; low capacitance; low leakage current

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

On-board charger block diagram



	Technology	Series
I	Fuse	10EV*, 20EV
	MOV	AUMOV
	GDT	CG2 , CG3
	SIDACtor	Pxx0FNL , Pxx0SD
II	Thyristor	S8016xA
III	Gate Driver	IXD_6xxSI , IX4340NE
IV	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
V	Gate Driver	IXD_6xxSI , IX4340NE
	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
VI	Fuse	10EV*, 20EV
	MOV	AUMOV
	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
VII	Diode Array	AQ24CANA

* Please contact Littelfuse Associates for details



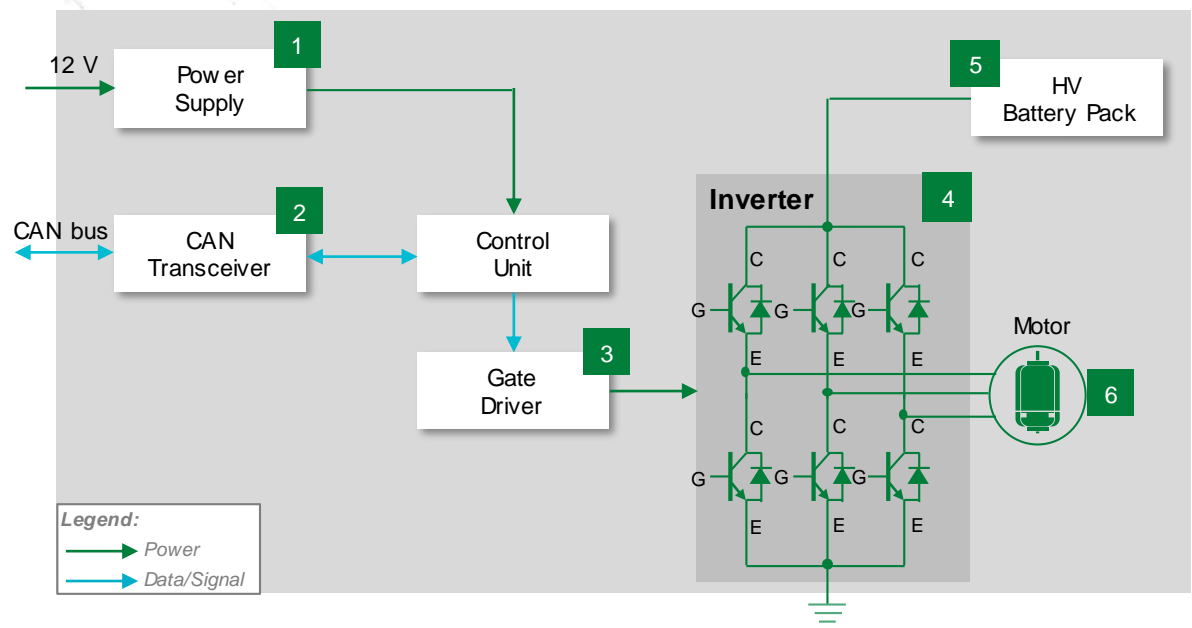
Click on the product series in the table below for more info

Benefits of Littelfuse products in on-board charger

	Technology	Function in application	Series	Benefits	Features
I	Fuse	Short Circuit Protection Overload Circuit Protection	10EV*, 20EV	Provides safety protection in high-voltage environments; full range fuse	Bolt down form factor; high breaking capacity; qualified to ISO 8820 standard
	MOV	Lightning and System Transient Surges	AUMOV	Clamps transient surge to ensure the reliable performance of the circuitry	Wide range of surge current ratings; disk sizes and lead options
	GDT	Ensures electrical isolation between Line, Neutral and Ground	CG2 , CG3	Provides safety to the system with high resistance isolation	Rugged, high surge current based on ceramic tube design; low leakage current
	SIDACTor	Lightning and System Transient Surges	Pxxx0FNL , Pxxx0SD	Used in combination with MOV; provides lower clamping voltage for sensitive circuitry	Surface mount form factor; semiconductor-based design provides no wear-out capability
II	Thyristor	Rectification	S8016xA	Reduces the in-rush current during rectification that can damage expensive DC Link Capacitor	Compact TO-220AQ and surface mount TO-263 form factors, V_{DRM} of 800 V, I_t of 25 A (rms)
III	Gate Driver	Controls the switching MOSFETs	IXD_6xxSI , IX4340NE	Dual outputs provide space efficient design, high immunity to latch-up; rise/fall times less than 10ns	Tight tolerance, small form factor; fast thermal response.
IV	TVS Diode	Active Clamping	TPSMB , SZ1SMB , SZP6SMB	Clamps the transient that is created when the MOSFET switches; ensuring reliability	Small form factor DO214-AA package; low clamping voltage
V	Gate Driver	Controls the switching MOSFETs	IXD_6xxSI , IX4340NE	Dual outputs provide space efficient design; high immunity to latch-up; rise/fall times less than 10 ns	Tight tolerance; small form factor; fast thermal response
	TVS Diode	Active Clamping	TPSMB , SZ1SMB , SZP6SMB	Clamps the transient that is created when the MOSFET switches; ensuring reliability	Small form factor DO214-AA package; low clamping voltage
	Diode Array	ESD protection of the Gate input	AQ4022	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
VI	Fuse	Short Circuit Protection Overload Circuit Protection	10EV*, 20EV	Provides safety protection in high-voltage environments; full range fuse	Bolt down form factor, high breaking capacity; qualified to ISO 8820 standard
	MOV	Transient Voltage Suppression	AUMOV	Clamps transient surge to ensure the reliable performance of the circuitry	Wide range of surge current ratings; disk sizes and lead options
	TVS Diode	Transient Voltage Suppression	TPSMB , SZ1SMB , SZP6SMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
VII	Diode Array	Protect CAN bus from ESD, EFT and voltage transient	AQ24CANA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage

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

Traction motor inverter block diagram



	Technology	Series
1	TVS Diode	TPSMB , TPSMA6L , SZ1SMB , SZP6SMB , SZ1SMA
	Fuse	441A
2	Diode Array	AQ24CANA
	Diode Array	AQ4022
3	TVS Diode	TPSMF4L , SZSMF
	IGBT Gate Driver	IXD_6xxSI , IX4340NE
4	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
5	Fuse	525*, 526*, 527
6	TVS Diode	TPSMB
	Thermal Protector Mini	HC RTP-mini

* Please contact Littelfuse Associates for details



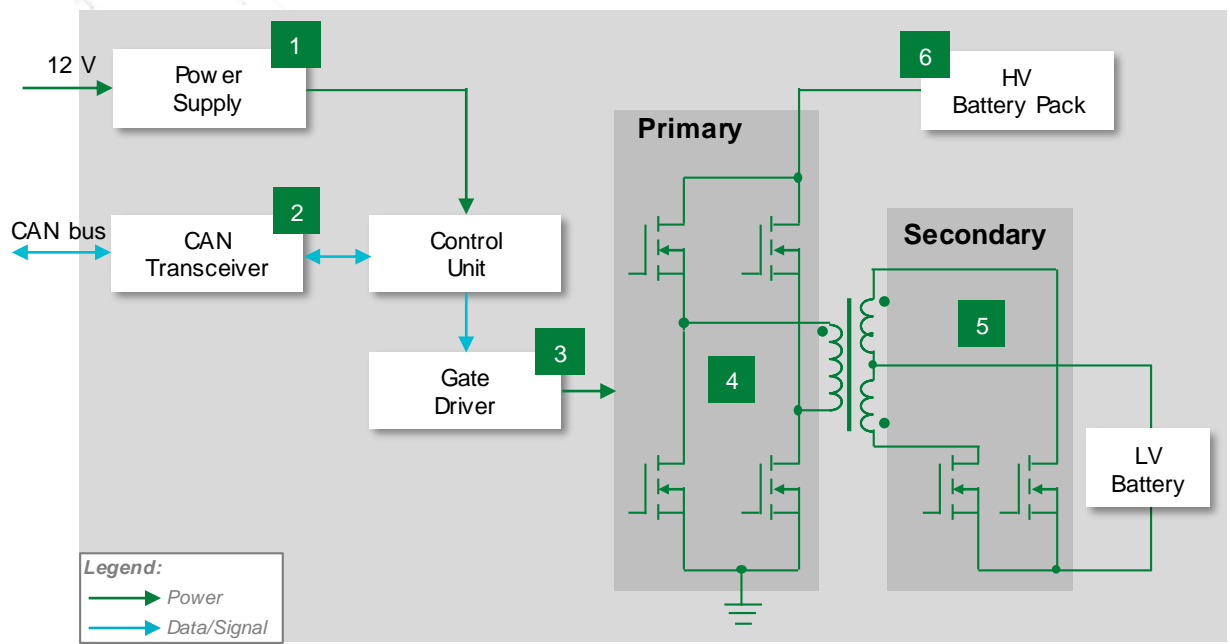
Click on the product series in the table below for more info

Benefits of Littelfuse products in traction motor inverter

	Technology	Function in application	Series	Benefits	Features
1	TVS Diode	Transient Voltage Suppression	TPSMB , TPSMA6L , SZ1SMB , SZP6SMB , SZ1SMA	Excellent clamping capability; meets automotive industry standards; fast response time; compact design	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	Fuse	Short circuit protection Overload circuit protection	441A	Excellent temperature stability and performance reliability; compact design; ceramic substrate ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
2	Diode Array	Protect CAN Bus from ESD, EFT and voltage transient	AQ24CANA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
3	Diode Array	ESD protection of the Gate input	AQ4022	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
	TVS Diode	Transient Voltage Suppression	TPSMF4L , SZSME	Excellent clamping capability; meets automotive industry standards; fast response time; compact design	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	IGBT Gate Driver	Controls the switching MOSFETs	IXD_6xxSI , IX4340NE	Dual outputs provide space efficient design, high immunity to latch-up, rise/fall times less than 10ns	Tight tolerance, small form factor, fast thermal response.
4	TVS Diode	Active clamping	TPSMB , SZ1SMB , SZP6SMB	Clamps the transient that is created when the MOSFET switches, ensuring reliability	Small form factor DO214-AA package, low clamping voltage
5	Fuse	Short Circuit Protection	525*, 526*, 527*	Provides safety protection from short circuit conditions	High voltage, ceramic body ensures compatibility with high temperature environment
6	TVS Diode	Transient Voltage Suppression	TPSMB	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	Thermal Protection Mini	Thermal protection for MOSFETs	HCRTP-mini	Responds to over-temperature conditions caused by catastrophic failure of MOSFET device	Surface mountable form factor, compatible with standard reflow process, breaks current flow during over temperature condition

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

DC/DC converter block diagram



	Technology	Series
1	TVS Diode	TPSMB , TPSMA6L , SZ1SMB , SZP6SMB , SZ1SMA
	Fuse	441A
	Thermal Protector Mini	HCRTP-mini
2	Diode Array	AQ24CANA
	Diode Array	AQ4022
3	TVS Diode	TPSMF4L
	IGBT Gate Driver	IXD_6xxSI , IX4340NE
4	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
	Fuse	525*, 526*, 527*
5	Thermal Protector Mini	HCRTP-mini
	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
6	TVS Diode	TPSMB , SZ1SMB , SZP6SMB
	IGBT Gate Driver	IXD_6xxSI , IX4340NE

* Please contact Littelfuse Associates for details



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

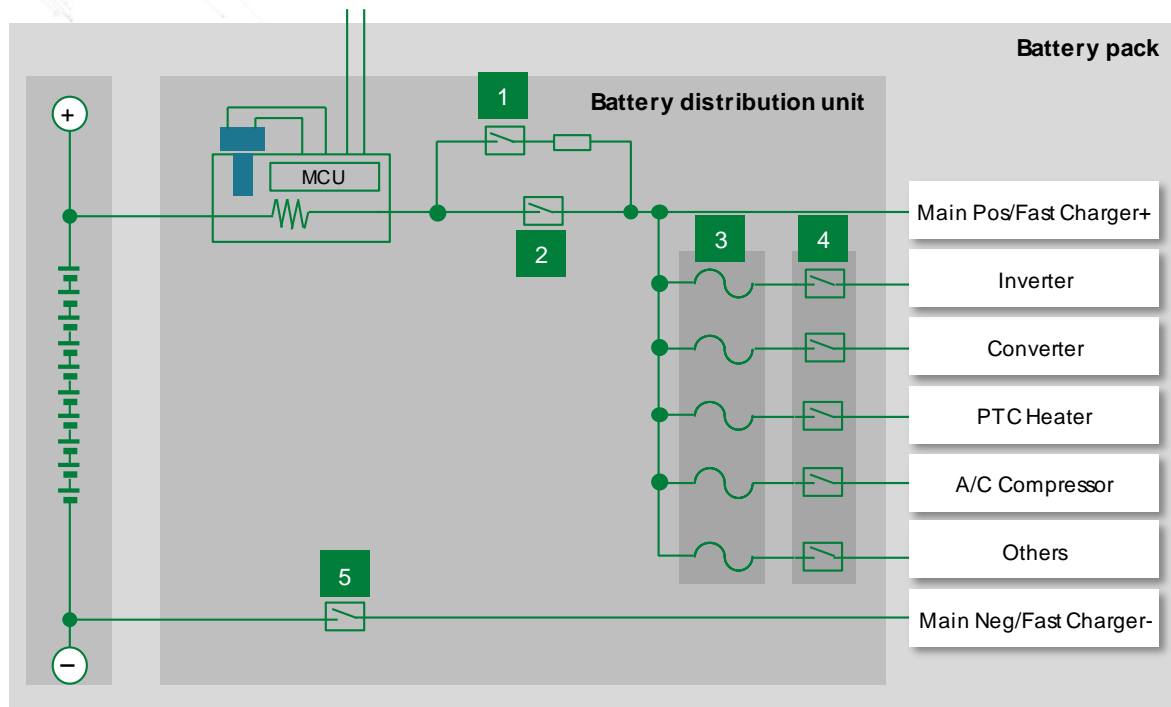
Benefits of Littelfuse products in DC/DC converter

	Technology	Function in application	Series	Benefits	Features
1	TVS Diode	Transient Voltage Suppression	TPSMB , TPSMA6L , SZ1SMB , SZP6SMB , SZ1SMA	Excellent clamping capability; meets automotive industry standards; fast response time; compact design	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	Fuse	Short circuit protection Overload circuit protection	441A	Excellent temperature stability and performance reliability; ceramic substrate ensures compatibility with high temperature environment	Tested to new AECQ specification; fast response to fault current; surface mount device
	Thermal Protection Mini	Thermal protection for MOSFETs	HCRTP-mini	Responds to over-temperature conditions caused by catastrophic failure of MOSFET device	Surface mountable form factor; compatible with standard reflow process; breaks current flow during overtemperature condition
2	Diode Array	Protect CAN bus from ESD, EFT and voltage transient	AQ24CANA	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
3	Diode Array	ESD protection of the gate input	AQ4022	Ensures reliability of the equipment without performance degradation	AEC-Q101 qualified; meets ESD protection levels specified under IEC 61000-4-2, ISO10605; low leakage current & clamping voltage
	Diode Array	Transient Voltage Suppression	TPSMF4L	Excellent clamping capability; meets automotive industry standards; fast response time	AEC-Q101 qualified; meets IEC standards for ESD protection & ISO for in-vehicle transient surges
	IGBT Gate Driver	Controls the switching MOSFETs	IXD 6xxSI , IX434QNE	Dual outputs provide space efficient design; high immunity to latch-up; rise/fall times less than 10 ns	Tight tolerance; small form factor; fast thermal response
4	TVS Diode	Active clamping	TPSMB , SZ1SMB , SZP6SMB	Clamps the transient that is created when the MOSFET switches; ensuring reliability	Small form factor DO214-AA package; low clamping voltage
5	Fuse	Short circuit protection	525*, 526*, 527*	Provides safety protection from short circuit conditions	High voltage; ceramic body ensures compatibility with high temperature environment
	Thermal Protection Mini	Thermal protection for MOSFETs	HCRTP-mini	Responds to over-temperature conditions caused by catastrophic failure of MOSFET device	Surface mountable form factor; compatible with standard reflow process; breaks current flow during overtemperature condition
6	TVS Diode	Active clamping	TPSMB , SZ1SMB , SZP6SMB	Clamps the transient that is created when the MOSFET switches; ensuring reliability	Small form factor DO214-AA package; low clamping voltage
	IGBT Gate Driver	Controls the switching MOSFETs	IXD 6xxSI , IX434QNE	Dual outputs provide space efficient design; high immunity to latch-up; rise/fall times less than 10ns	Tight tolerance; small form factor; fast thermal response



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

Battery distribution unit block diagram



	Technology	Series
1	Pre-charge Contactor	DCNSEV , DCNLEV
2	Main Positive Contactor	DCNEV
3	Auxiliary Fuse	10EV*, 20EV , SHEV
4	Auxiliary Contactor	DCNEV , DCNLEV
5	Main Negative Contactor	DCNEV

* Please contact Littelfuse Associates for details

Benefits of Littelfuse products in battery distribution unit



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

	Technology	Function in application	Series	Benefits	Features
1	Pre-charge Contactor	Used to protect the main contactors from an excess inrush current, a pre-charge contactor is used together with a pre-charge resistor, to charge the capacitors of the power inverter to a level of typically 90–98% of the battery voltage	DCNEV , DCNLEV	Allows a low voltage signal to switch the contacts for a high voltage signal	Wide range of capabilities – can switch from 10's of amps to 1000's of amps, and 10's of volts to 1000's of volts
2	Main Positive Contactor	The main contactors connect and disconnect the traction battery from the entire electric drivetrain in the vehicle	DCNEV	Allows a low voltage signal to switch the contacts for a high voltage signal	Wide range of capabilities – can switch from 10's of amps to 1000's of amps, and 10's of volts to 1000's of volts
3	Auxiliary Fuse	Short Circuit Protection Overload Circuit Protection	10EV*, 20EV , SHEV	Provides safety protection in high-voltage environments, full range fuse. Can protect the entire pack's voltage and short circuit current	Bolt down form factor, high breaking capacity, qualified to ISO 8820 standard
4	Auxiliary Contactor	Control other electrical loads in the vehicle that are operated by the HV battery (For example, Electric heater, blower, A/C compressor, power steering pump, etc.)	DCNEV , DCNLEV	Allows a low voltage signal to switch the contacts for a high voltage signal	Wide range of capabilities – can switch from 10's of amps to 1000's of amps, and 10's of volts to 1000's of volts
5	Main Negative Contactor	The main contactors connect and disconnect the traction battery from the entire electric drivetrain in the vehicle	DCNEV	Allows a low voltage signal to switch the contacts for a high voltage signal	Wide range of capabilities – can switch from 10's of amps to 1000's of amps, and 10's of volts to 1000's of volts

* Please contact Littelfuse Associates for details

Select standards for automotive applications

Standard	Title	General scope	Littelfuse Technology	Region
ISO7637-2	Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only	Specifies test methods and procedures to ensure the compatibility to conducted electrical transients of equipment installed on passenger cars and commercial vehicles fitted with 12 V or 24 V electrical systems. It describes bench tests for both the injection and measurement of transients. It is applicable to all types of road vehicles independent of the propulsion system (For example, spark ignition or diesel engine, electric motor).	TVS Diode	Global
ISO16750-2	Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads	This standard applies to electric and electronic systems/components for road vehicles. It describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the road vehicle.	TVS Diode	Global
ISO 10605:2008	Road vehicles – Test methods for electrical disturbances from electrostatic discharge	This standard specifies the electrostatic discharge (ESD) test methods necessary to evaluate electronic modules intended for vehicle use. It includes these sources of ESD: in assembly, by service staff, by vehicle occupants.	Diode Array PulseGuard® (AXGD) Multilayer Varistor	Global

Additional information can be found on littelfuse.com

Circuit Protection
Selection Guide



Automotive Electronics
Application Guide



ESD Suppression
Selection Guide

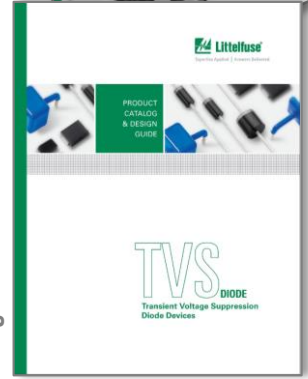


ESD Protection
Selection Guide

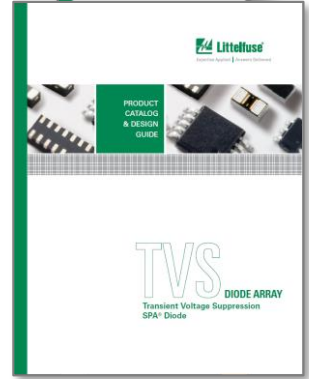


Click on each
image to open the
catalog

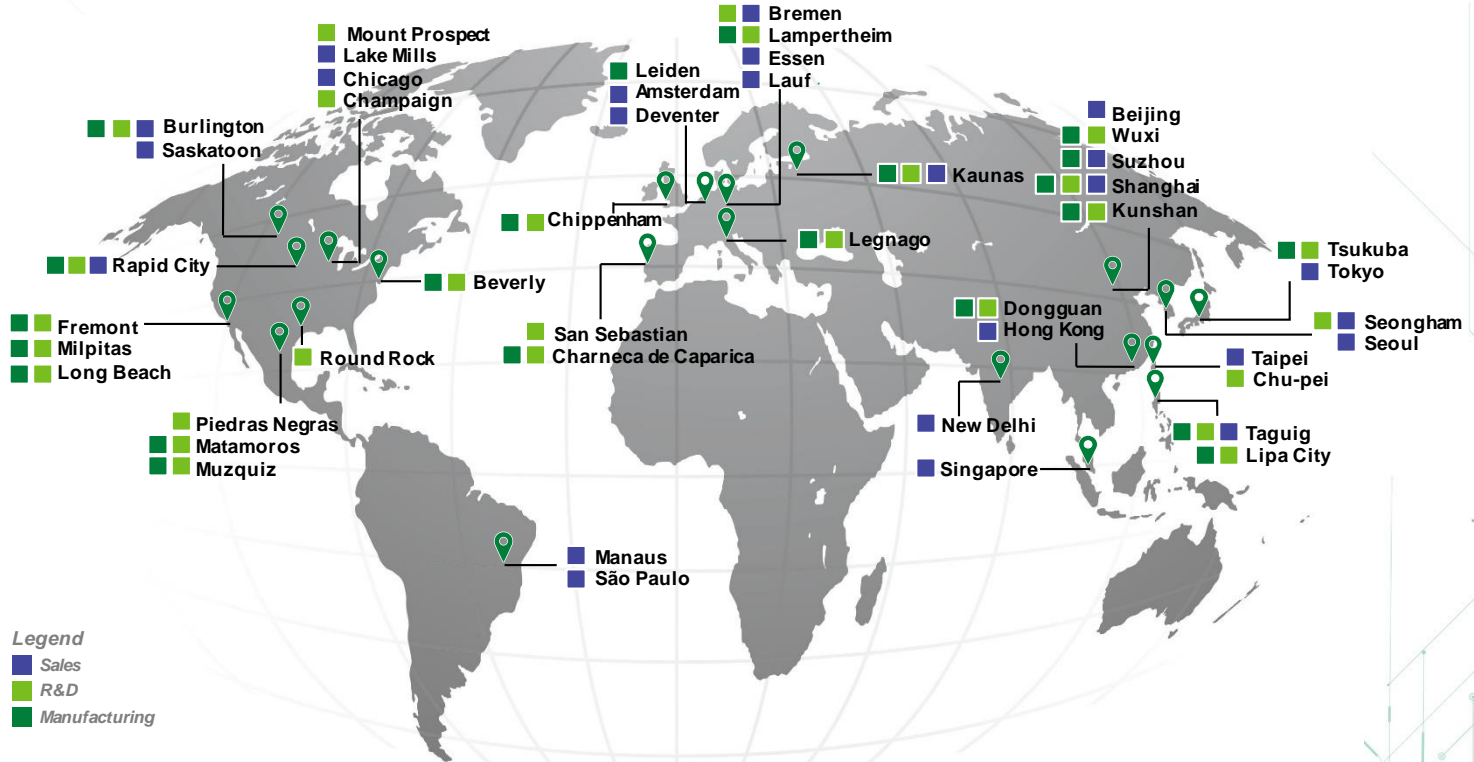
TVS Diode Catalog and
Design Guide



TVS Diode Array
Selection Guide



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 market faster, we offer certification testing to global regulatory standards

Global manufacturing

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



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