



Supercharged Solutions for **EV Charging Stations**



Supercharged Solutions to Enhance Safety, Efficiency, & Reliability

About This Guide

This guide provides an overview of the Littelfuse technologies available for use in various EV charging applications. It is designed to help you quickly find circuit protection, power control, and sensing solutions appropriate for your design.

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Charging Ahead with eMobility

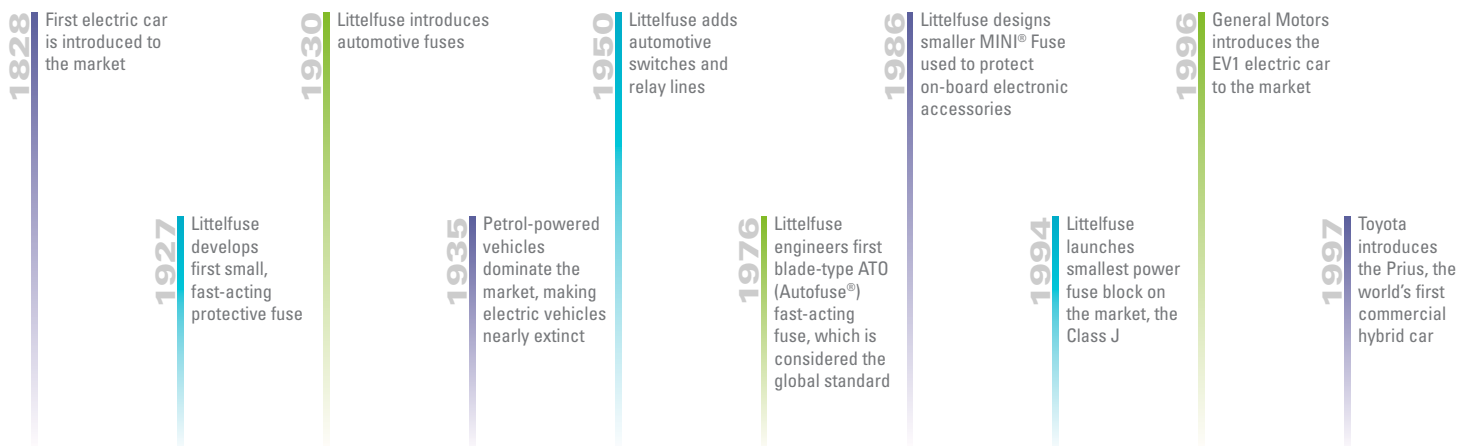
Littelfuse has a long history of pioneering innovative products that drive technological advances. Since its founding in 1927, our company has gone on to define the industry standard for automotive fuses and become a global leader in circuit protection, power control, and sensing.

Our commitment to the automotive industry continues today, as it enters a new era of innovation. The future of cars and mobility is electric. As the demand for electric vehicles grows, so does the need for reliable and safe charging systems.

Littelfuse application expertise has helped to engineer some of the most advanced systems for EV charging stations. Let our team of experts show you how to build safety, efficiency and reliability into your designs.

Whether you are developing alternating current (AC) charging systems, which provide AC power to a vehicle's on-board charger, or direct current (DC) fast chargers, which provide DC power to a vehicle's battery system, you need a partner that can help you meet three key goals.

Milestones in eMobility





Safety

The two biggest safety threats in an EV charging station are electrical shock and overcurrent. Electrical shock is usually the result of a ground fault.

Electrical Shock

A ground fault is an unintended contact between an energized conductor and ground or the equipment frame. Insulation breakdown is the typical culprit. Dust and moisture can also cause unintended pathways for electricity. Wet and dusty environments, such as those found around outdoor equipment, require diligence in design.

Overcurrent

By their nature, vehicle charging stations are connected to a power supply that has high available fault current. Electrical faults, including those that start ground faults, can draw high current that can be very destructive, damaging components, twisting bus bars, starting fires, even causing an arc-flash incident—a kind of explosion that could injure or kill anyone standing nearby.

Efficiency

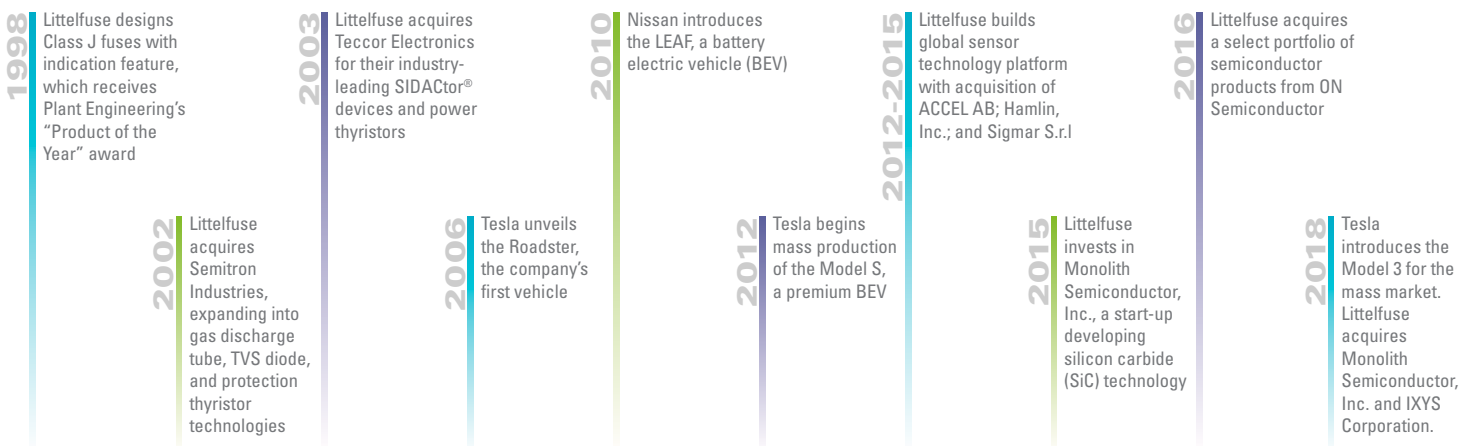
Power semiconductor devices convert AC power into the DC power needed to recharge vehicle batteries. To match the level of charge to what the vehicle battery needs, the power semiconductor device controls the charge through switching, a process that naturally incurs power losses in the form of heat. In an EV charging application, heat can create engineering challenges.

SiC MOSFET devices are now available that blend high operating voltages and fast switching speeds, a combination typically not available with traditional power transistors. To be useful in automotive charging applications, they must operate at high junction temperatures and feature low gate resistance, low gate charge, low output capacitance, and ultra-low on-resistance. Designers prefer devices that offer high power density and reduce the size and weight of filter components, which reduces cost and space requirements.

Reliability

Unlike consumer devices like laptops that are engineered for a lifetime of three to five years, DC charging stations are expensive, so buyers need them to last for 10 years or more in order to get a return on their investment. The value of semiconductor content alone ranges from \$350 in an AC charger to more than \$3,500 in a 350 kW charging system. Proper circuit protection will keep that investment working reliably for a longer.

Semiconductor devices are sensitive to electrical threats and must be protected from overcurrent by fuses. These devices are typically fabricated from silicon or silicon carbide and have low thermal withstand capacity.





AC Charging Station

Although simpler in nature than DC chargers, AC charging stations safely deliver AC power from the electrical grid to the vehicle. Due to space and weight constraints in the vehicle, on-board chargers and AC charging stations are typically limited to lower amounts of power (22 kW or less), which means charging time is slow — taking several hours. These systems also rely on a vehicle's on-board charger to enable the conversion of AC power from the grid into DC power to charge the vehicle's battery. It is critical that proper measures are taken to safeguard both the charger and vehicle.

1 Input Protection

Fuse, MOV, GDT, TVS Diode

2 Auxiliary Power Supply

Schottky Diode, SIDACTor® + MOV

3 Communication

TVS Diode Array, Reed Relay

4 User Interface

TVS Diode Array,
Polymer ESD Suppressor

5 Service Access Panel

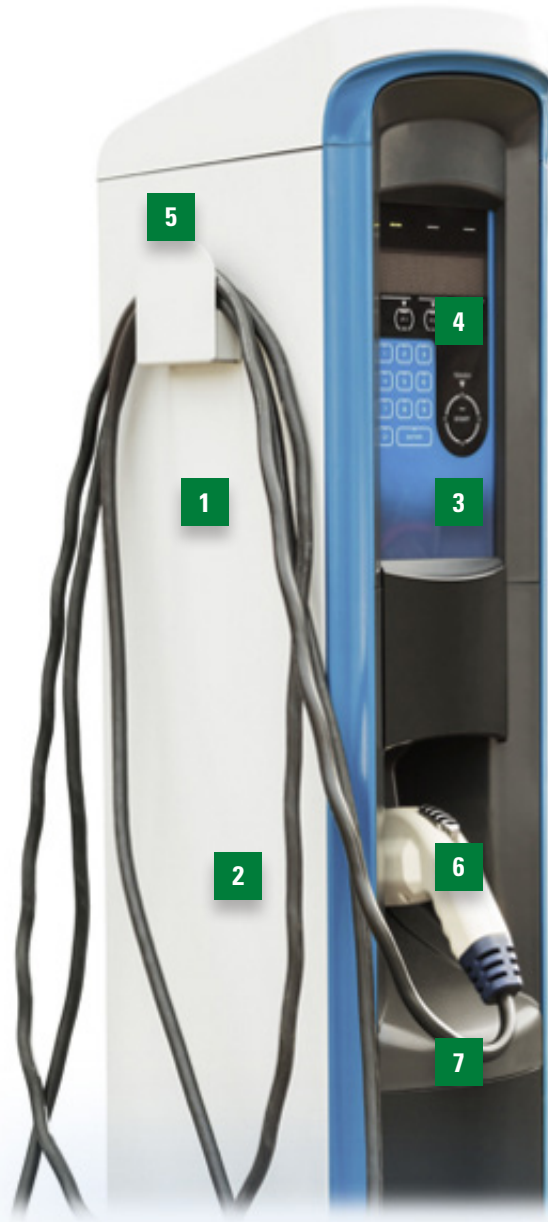
Reed Sensor

6 Charging Plug

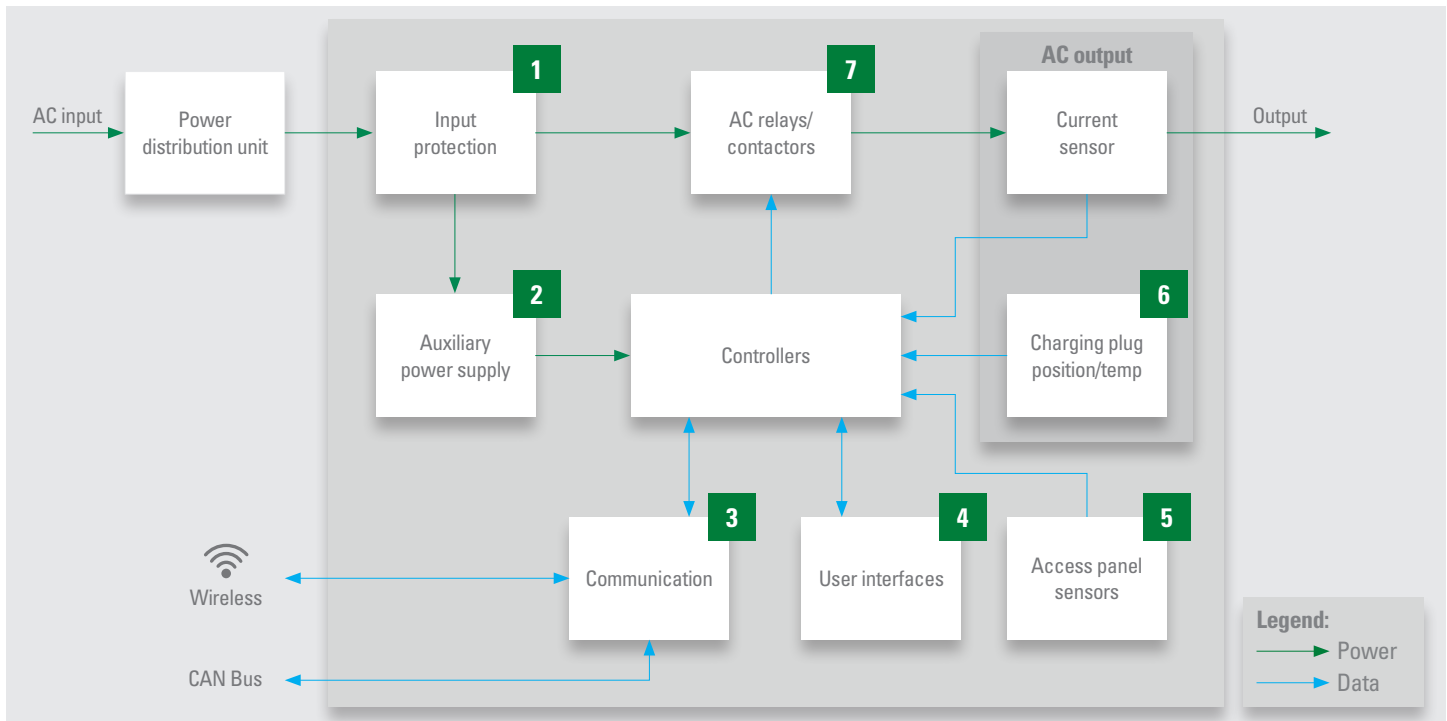
Temperature Sensor, Reed Sensor

7 AC Relays/Contactor

Contactors & Relays



AC Charging Station



	Technology	Function in Application	Product Series	Features
1	High-Current Fuse (Primary Protection)	Primary over-current protection of EV equipment	606	Rated voltage @ 500 VAC; 40 A to 63 A rating available; small footprint
	Surge protection (Primary protection)	Protects from power fluctuations or surges	SPD Type 2	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
	Fast-Acting Fuse (Secondary Protection)	Overcurrent protection of auxiliary power supply	215, 314, 324	In accordance with UL Standard 248-14; available in cartridge and axial lead format
	MOV	GDT in series with TMOV protects the auxiliary power supply unit from voltage transients induced by lightning	TMOV, UltraMOV	High energy absorption capability: 40–530 J (2 ms); integrated thermal protection
	GDT		CG2, CG3	High energy absorption capability; small form-factor; low leakage current
		TVS Diode	Protects power line from transient surge	High Voltage AK
2	Schottky Diode	Used for rectification	DST, DSA, DSB	High surge capability; negligible reverse recovery current; T _J = 175 °C
	SIDACtor® + MOV	Enhancing surge protection for auxiliary power supply	Pxxx0FNL + UltraMOV	3 kA, 8/20 μs surge capability to help protect AC lines from harmful transient surges.
3	TVS Diode Array	Protects CAN bus from ESD, EFT, and voltage transient	AQ24CAN, SM24CANx	Meets ESD protection levels specified under IEC 61000-4-2; ISO10605; low leakage current and clamping voltage
	Reed Relay	Low power switching with up to 2500 V isolation	HE3600	Miniature single in-line package; external magnetic shield option
4	TVS Diode Array, Polymer ESD	Protects ICs from ESD through display	SP1026, XGD10402	SP1026 has high ESD robustness for touchpads; XGD10402 has ultra-low capacitance for high-speed data lines
5	Reed Sensor	Access panel for position sensing	59060, 59045	Well suited for usage in high-moisture and contaminated environments; molded stand-off to allow board washing
6	Temperature Sensor	Temperature sensing	PPG, USW, Glass Coated Thermistor	Linear relationship between temp and resistance; temp range -50 °C to +500 °C
	Reed Sensor	Charging plus position sensing	59060, 59045	Hermetically sealed, magnetically operated contacts; certified for use in North America and Europe
7	Contactors or Relays	Safety cutoff on the grid (power network) to prevent abnormal current supply.	HCC 1 & 2 Pole, HCC 3 & 4 Pole, HCD	Long electrical life; High surge capability; Certified for use in North America, Europe and Asia
			SCO1*, SCO2*	Low heat generation and low coil power consumption; performance to meet regulatory compliance for instance (UL840, IEC61810-1, IEC60947-1)

* Please contact Littelfuse sales for more details
Littelfuse.com



DC Charging Station

DC charging stations are designed to convert the electrical grid's AC power into DC power that can then be fed directly into a vehicle's battery system for fast charging — in 30 minutes or less. Because the conversion from AC to DC power is being done in the charging station, these units can provide higher levels of power (50 kW to 350 kW and beyond) to the vehicle than AC charging stations. Working with tens to hundreds of kilowatts of power, efficient conversion, reliability of the system, and user safety are critical.

1 Power Distribution Unit

Fuse

2 Input Protection

Fuse, Surge Protection Device, TVS Diode, Current Transformer, AC Earth Fault Relay

3 Auxiliary Power Supply

Fuse, MOV, GDT, SIDACtor® + MOV, Si MOSFET, Rectifier Diode

4, 5 Rectification & PFC

SiC/Si MOSFET, Rectifier Diode/Module, Gate Driver, Temperature Sensor

8, 9 High-Frequency Converter

SiC/Si MOSFET, Rectifier Diode/Module, Gate Driver, Temperature Sensor

10,11 DC Output Protection

DC Fuse, HVDC Contactor, Earth Fault Relay

12 Charging Plug

Temperature Sensor, Reed Sensor

13 Communication

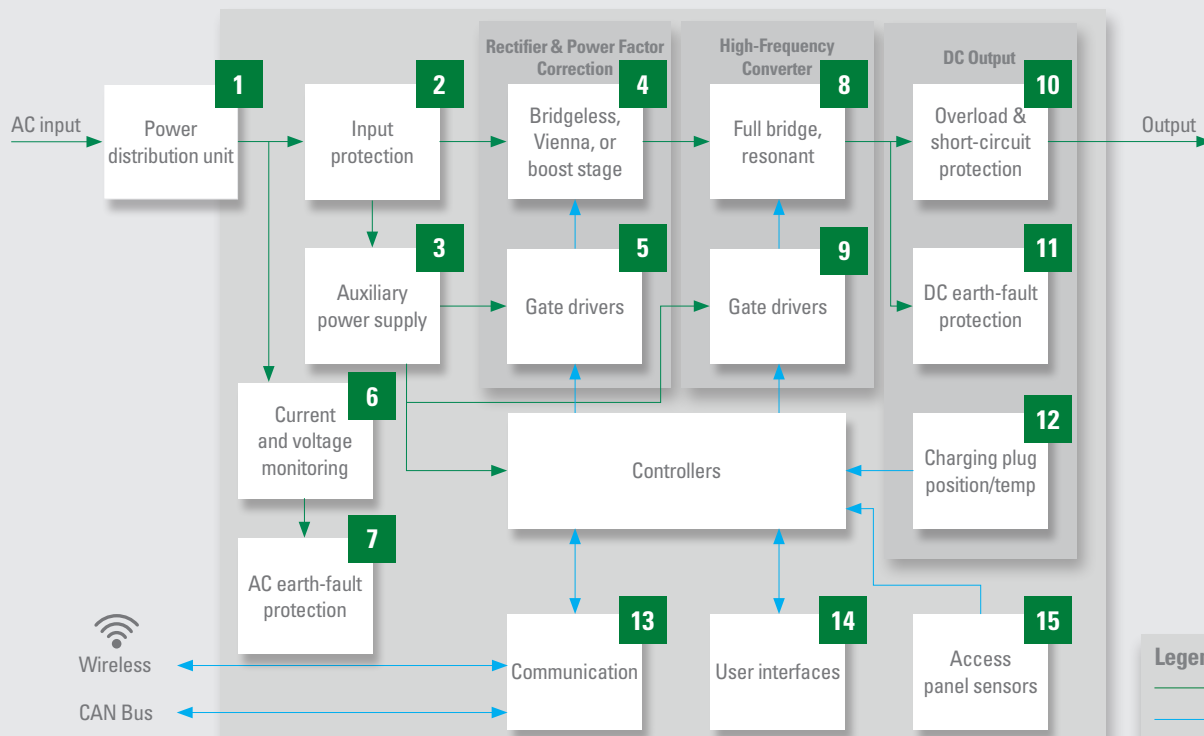
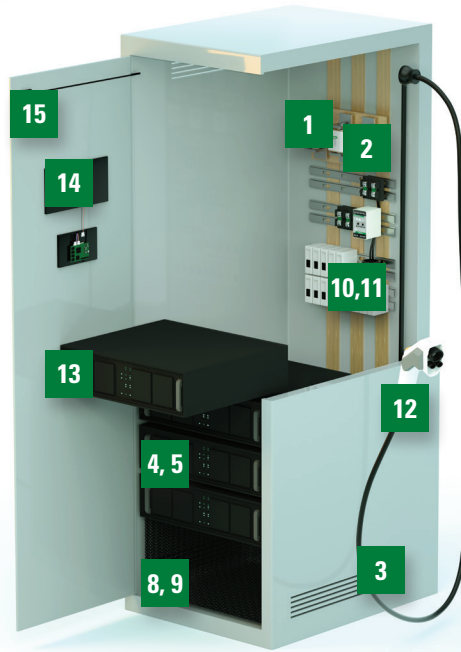
TVS Diode Array

14 User Interface

TVS Diode Array, Polymer ESD Suppressor

15 Service Access Panel

Reed Sensor



Note: Power converter topologies may differ based on design-specific requirements.

Legend:
 → Power
 → Data

DC Charging Station

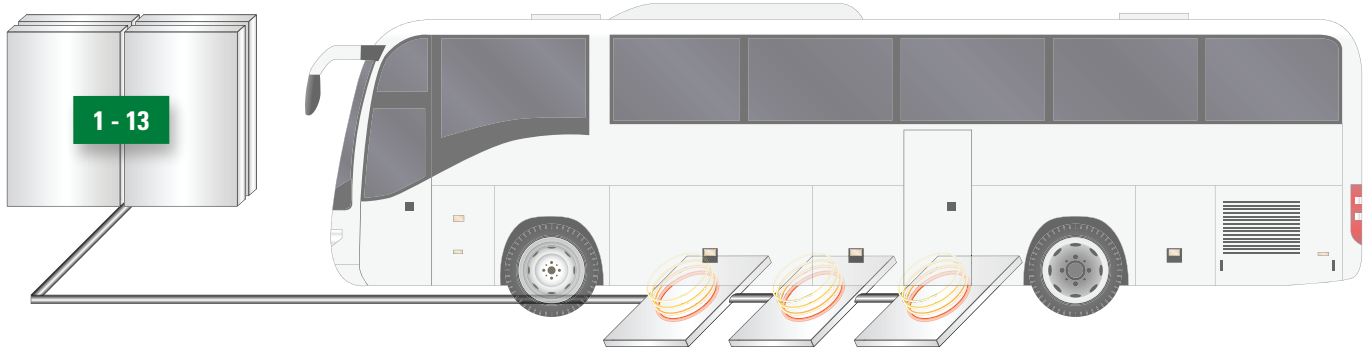
	Technology	Function in Application	Product Series	Features
1	AC Fuse (PDU Level)	Provide fast-acting overload and short circuit protection	JLLS, JLLN	Extremely current-limiting; Small footprint 200 kA interrupting rating
2	Overcurrent Protection (Primary Protection)	Protects semiconductor devices	PSR, L50QS, L75QS	550–1300 V _{AC} , 500–1000 V _{DC} , 40–2000 A
	Surge protection (Primary protection)	Protects from power fluctuations or surges	SPD Type 2	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
3	TVS Diode	Protects power line from transient surge	AK6, 1.5SMC	High power TVS 8/20 μs rating from 1 kA to 20 kA in axial-lead or SMT form factor
	Si MOSFET	High-speed switching	Polar™	Low RDS(ON) and Qg; avalanche rated; international standard packages; low package inductance
	Rectifier and Schottky Diode	Provides output rectification in auxiliary power supply	DMA, DST, DSA, DSB	Low forward voltage drop; high-frequency operation; high junction temperature
	AC Fuse (Secondary Protection)	Overcurrent protection of auxiliary power supply	314, 324	In accordance with UL Standard 248-14; available in cartridge and axial-lead format
	MOV	GDT in series with TMOV protects the auxiliary power supply unit from voltage transients induced by lightning	TMOV, UltraMOV	High energy absorption capability; 40–530 J (2 ms); integrated thermal protection
	GDT		CG2, CG3	High energy absorption capability; small form factor; low leakage current
	SIDACTor® + MOV	Enhancing surge protection for auxiliary power supply	Pxxx0FNL + UltraMOV	3 kA, 8/20 μs surge capability to help protect AC lines from harmful transient surges.
4	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	DMA	Low leakage current and forward voltage drop; improved thermal behavior; high robustness
	Rectifier Module	Converts AC line voltage supplied to the drive to DC	MDD, VUO, MDNA	Package with DCB ceramic; very low forward voltage drop and low leakage current
	SiC/Si MOSFET/ Discrete IGBT	Boost converter for high-frequency switching in the PFC circuit	LSIC1M0/ X2-Class/XPT	Ultra-low output capacitance and on-resistance
	Diode		LSIC2SD, DHG, DSEI	High surge capability; negligible I _{RR} ; T _J 175 °C
	Temperature Sensor	Semiconductor temperature measurement	USUR1000, KC	UL recognized; wide range of temperature: -40 °C to 125 °C
5	Gate Driver	Controls the switching MOSFETs/IGBTs	IXDN609, IX4351NE	9 A peak current; low propagation delay time; low output impedance
6	Current Transformer	Offers ground-fault detection and protection	SE-CS30	Turns ratio 600:1 and current rating 30:0.05 A
7	AC Earth-Fault Relay	Offers ground-fault detection and protection	SE-704	Microprocessor-based; adjustable pickup (10 mA–5 A); Adjustable time delay (30 ms–2 s)
8	SiC or Si MOSFET	High-frequency switching and rectification	LSIC1M0, X-Class, X2-Class, HiPerFET™	Ultra-low output capacitance and on-resistance
	Diode		LSIC2SD, DHG, DSEI	High surge capability; negligible I _{RR} ; T _J 175 °C
	Temperature Sensor	Semiconductor temperature measurement	USUR1000, KC	UL recognized; wide range of temperature: -40 °C to 125 °C
9	Gate Driver	Controls the switching MOSFETs	IXDN609, IX4351NE	9 A peak current; low propagation delay time; low output impedance
10	DC Fuse	Protects semiconductor devices	PSR, SFPJ	550–1300 V _{AC} , 500–1000 V _{DC} , 40–2000 A
	Diode	CHAdeMO standard requires safety diode for secondary protection	DMA, DHG, DSEI	High voltage options; very low forward voltage drop; small form factor
	HV DC Contactors	The main contactors connect and disconnect the DC charging unit	DCNxx	Wide range of capabilities—can switch from 10 of amps to 1000 of amps, and 10 of volts to 1000 of volts
11	DC Earth-Fault Relay	Offers low-level ground-fault protection. Ground-fault current is sensed using a ground-reference Module.	SE-601	Adjustable pickup (1–20 mA); adjustable time delay (50 ms–2.5 s); CSA certified, UL Listed (E340889), CE (European Union), C-Tick
	Earth Reference Module		SE-GRM	
12	Temperature Sensor/ Temperature Indicator	Temperature sensing	PPG, USW, Glass Coated Thermistor, setPTM	Linear relationship between temp and resistance; temp range -50 °C to +500 °C
	Reed Sensor	Charging plus position sensing	59060, 59045, Glass Coated Thermistor	Hermetically sealed, magnetically operated contacts; certified for use in North America and Europe
13	TVS Diode Array	Protects CAN bus from ESD, EFT, and voltage transient	59060, 59045	Meets ESD protection levels specified under IEC 61000-4-2; ISO10605; low leakage current and clamping voltage
14	TVS Diode Array Polymer ESD	Protects ICs from ESD through display	AQ24CAN, SM24CANx	SP1026 has high ESD robustness for touchpads XGD10402 has ultra-low capacitance for high-speed data lines
15	Reed Sensor	Access panel for position sensing	SP1026, XGD10402	Hermetically sealed; magnetically operated contacts; certified for use in NA and Europe



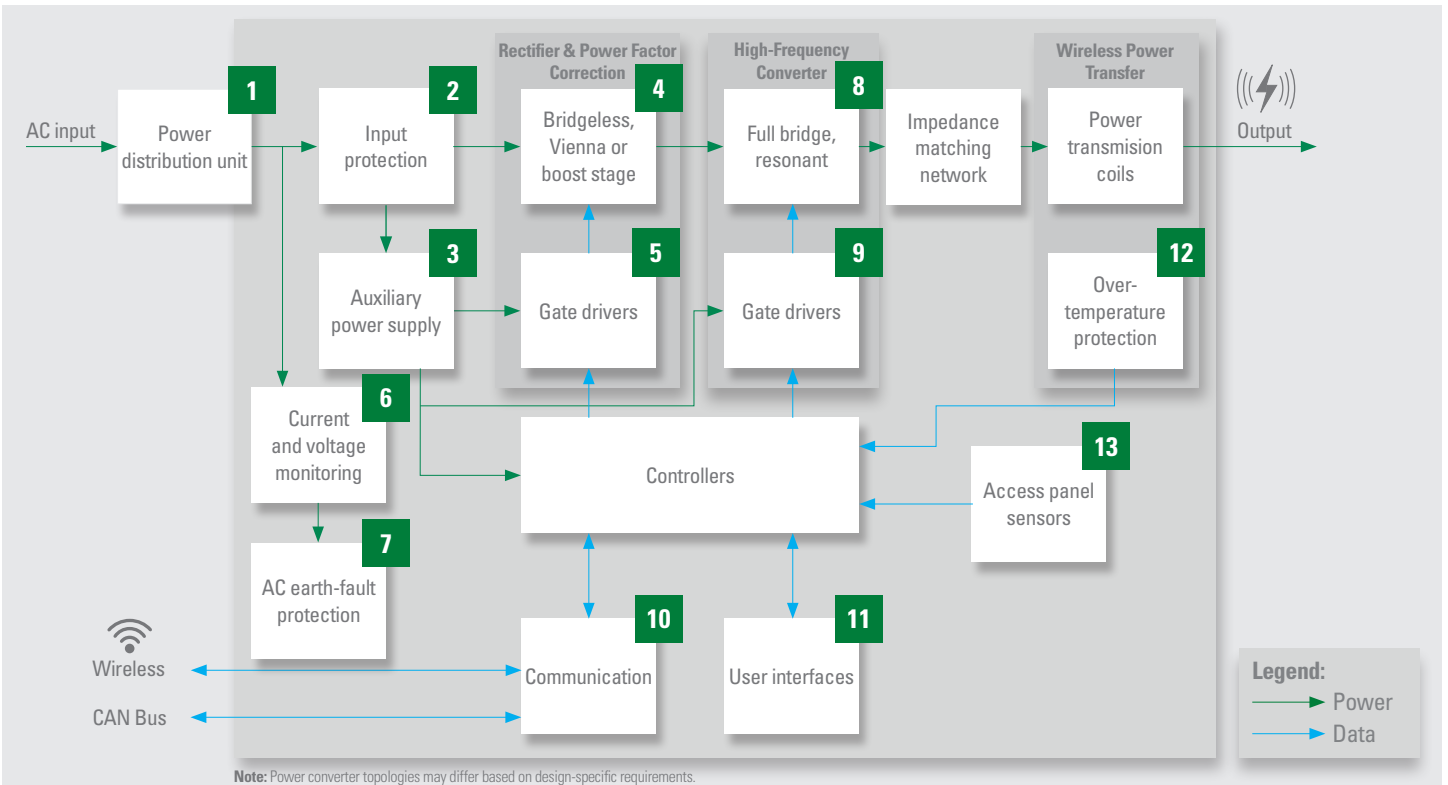
Wireless Charging Station

Wireless charging is an emerging application with distinct needs. The power module needs circuit protection devices, power rectifiers, gate drivers, power converters, and temperature sensors. There are similar requirements for the auxiliary power supply. Security sensors may be needed in the service access panel. Fuses and ground-fault relays are needed in the electrical distribution.

1 Power Distribution Unit	2 Input Protection	3 Auxiliary Power Supply	4, 5 Rectification & PFC
Fuse	Fuse, Surge Protection Device, TVS Diode, Current Transformer, AC Fault Relay	Fuse, MOV, GDT, SIDACTor® + MOV, Si MOSFET, Rectifier Diode	SiC/Si MOSFET, Rectifier Diode/Module, Gate Driver, Temperature Sensor



8, 9 High-Frequency Converter	10 Communication	11 User Interface	13 Service Access Panel
SiC/Si MOSFET, Gate Driver, Temperature Sensor	TVS Diode Array	TVS Diode Array, Polymer ESD Suppressor	Reed Sensor



Wireless Charging Station

	Technology	Function in Application	Product Series	Features
1	AC Fuse (PDU Level)	Provide fast-acting overload and short circuit protection	JLLS, JLLN, KLKD	Extremely current-limiting; small footprint 200 kA interrupting rating
2	Overcurrent Protection (Primary Protection)	Protects semiconductor devices	PSR, L50QS, L75QS	550–1300 V _{AC} , 500–1000 V _{DC} , 40–2000 A
	Surge protection (Primary protection)	Protects from power fluctuations or surges	SPD Type 2	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
	TVS Diode	Protects power line from transient surge	High Voltage AK, LTKAK	High power TVS 8/20 μs rating from 1 kA to 20 kA in axial-lead or SMT form factor
3	Si MOSFET	High-speed switching	Polar™	Low RDS(ON) and Qg; avalanche rated; international standard packages; low package inductance
	Rectifier and Schottky Diode	Provides output rectification in auxiliary power supply	DMA, DST, DSA, DSB	Low forward voltage drop; high-frequency operation; high junction temperature
	AC Fuse (Secondary Protection)	Overcurrent protection of auxiliary power supply	314, 324	In accordance with UL Standard 248-14; available in cartridge and axial-lead format
	MOV	GDT in series with TMOV protects the auxiliary power supply unit from voltage transients induced by lightning	TMOV, UltraMOV	High energy absorption capability: 40–530 J (2 ms); integrated thermal protection
	GDT		CG2, CG3	High energy absorption capability; small form factor; low leakage current
	SIDACTor® + MOV	Enhancing surge protection for auxiliary power supply	Pxxx0FNL + UltraMOV	3 kA, 8/20 μs surge capability to help protect AC lines from harmful transient surges.
4	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	DMA	Low leakage current and forward voltage drop; improved thermal behavior; high robustness
	Rectifier Module	Converts AC line voltage supplied to the drive to DC.	MDD, VUO, MDNA	Package with DCB ceramic; very low forward voltage drop and low leakage current
	SiC/Si MOSFET/ Discrete IGBT	Boost converter for high-frequency switching in the PFC circuit	LSIC1M0/ X2-Class/XPT	Ultra-low output capacitance and on-resistance
	Diode		LSIC2SD, DHG, DSEI	High surge capability; negligible I _{RR} ; T _j 175 °C
	Temperature Sensor	Semiconductor temperature measurement	USUR1000, KC	UL recognized; wide range of temperature: -40 °C to 125 °C
5	Gate Driver	Controls the switching MOSFETs/IGBTs	IXDN609, IX4351NE	9 A peak current; low propagation delay time; low output impedance
6	Current Transformer	Offers ground-fault detection and protection	SE-CS30	Turns ratio 600:1 and current rating 30:0.05 A
7	AC Earth-Fault Relay	Offers ground-fault detection and protection	SE-704	Microprocessor-based; adjustable pickup (10 mA–5 A); Adjustable time delay (30 ms–2 s)
8	SiC or Si MOSFET	High-frequency switching and rectification	LSIC1M0	Ultra-low output capacitance and on-resistance
	Temperature Sensor	Semiconductor temperature measurement	USUR1000, KC	UL recognized; wide range of temperature: -40 °C to 125 °C
9	Gate Driver	Controls the switching MOSFETs/IGBTs	IXDN609, IX4351NE	9 A peak current; low propagation delay time; low output impedance
10	TVS Diode Array	Protects CAN bus from ESD, EFT, and voltage transient	AQ24CAN, SM24CANx	Meets ESD protection levels specified under IEC 61000-4-2; ISO10605; low leakage current and clamping voltage
11	TVS Diode Array, Polymer ESD	Protects ICs from ESD through display	SP1026, XGD10402	SP1026 has high ESD robustness for touchpads; XGD10402 has ultra-low capacitance for high-speed data lines
12	Temperature Sensor	Temperature sensing	PPG, USW, Glass Coated Thermistor	Linear relationship between temp and resistance; temp range -50 °C to +500 °C
13	Reed Switch	Charging plus position sensing	59060, 59045	Hermetically sealed; magnetically operated contacts; certified for use in North America and Europe

About Littelfuse

About Littelfuse

Littelfuse (NASDAQ: LFUS) is an industrial technology manufacturing company empowering a sustainable, connected, and safer world. Across more than 15 countries, and with 12,000 global associates, we partner with customers to design and deliver innovative, reliable solutions. Serving over 100,000 end customers, our products are found in a variety of industrial, transportation, and electronics end markets—everywhere, every day. Learn more at Littelfuse.com.

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 is 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 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:

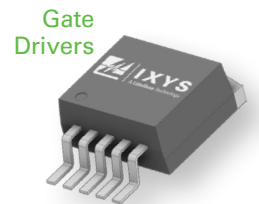
- ISO 9001
- ISO14001
- IATF 16949



Fuses



TVS Diode Arrays



Gate Drivers



Multi-Oxide Varistors



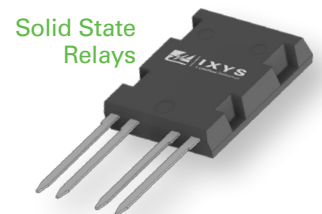
Surge Protection Devices



High-Speed Fuses



Industrial & UL-Class Fuses



Solid State Relays

Additional Resources



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Circuit Protection Products Selection 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 for your application.



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Sensing Products Selection Guide

This guide provides an overview of magnetic and temperature sensing technologies, key consideration factors, descriptions of technologies Littelfuse offers, and product selection tables to help you quickly find the sensing solution appropriate for your application.



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Power Semiconductor Catalog

This catalog represents the powerful combination of IXYS: A Littelfuse Technology. It offers a comprehensive portfolio of advanced power semiconductor technologies, including silicon and wide bandgap solutions in discrete and module packages.



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Protection Relays and Controls Catalog

This catalog includes a comprehensive line of motor and pump protection relays, arc-flash relays, ground-fault relays, feeder protection, pump controllers, time delay relays, flashers and tower lighting, and more to minimize electrical safety hazards, limit equipment damage, improve productivity, and safeguard personnel from injury due to electrical faults.



Discrete
MOSFETs



PPTCs



TVS Diodes



SMD
Fuses



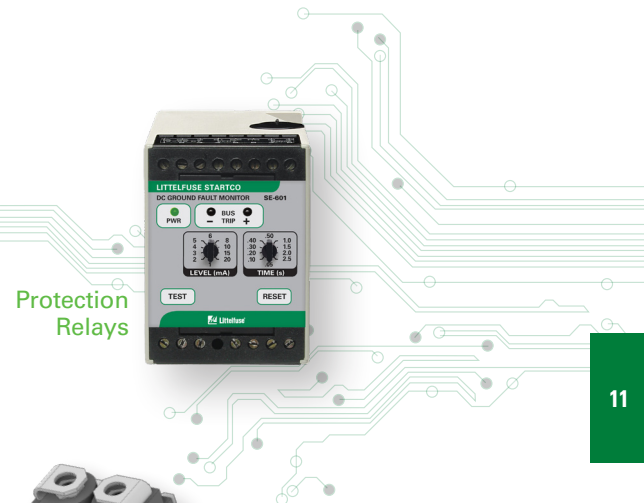
Reed
Sensors



Reed
Switches



Discrete
IGBTs



Protection
Relays

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Littelfuse engineers are a phone call away to help identify potential issues and provide product recommendations to solve problems.

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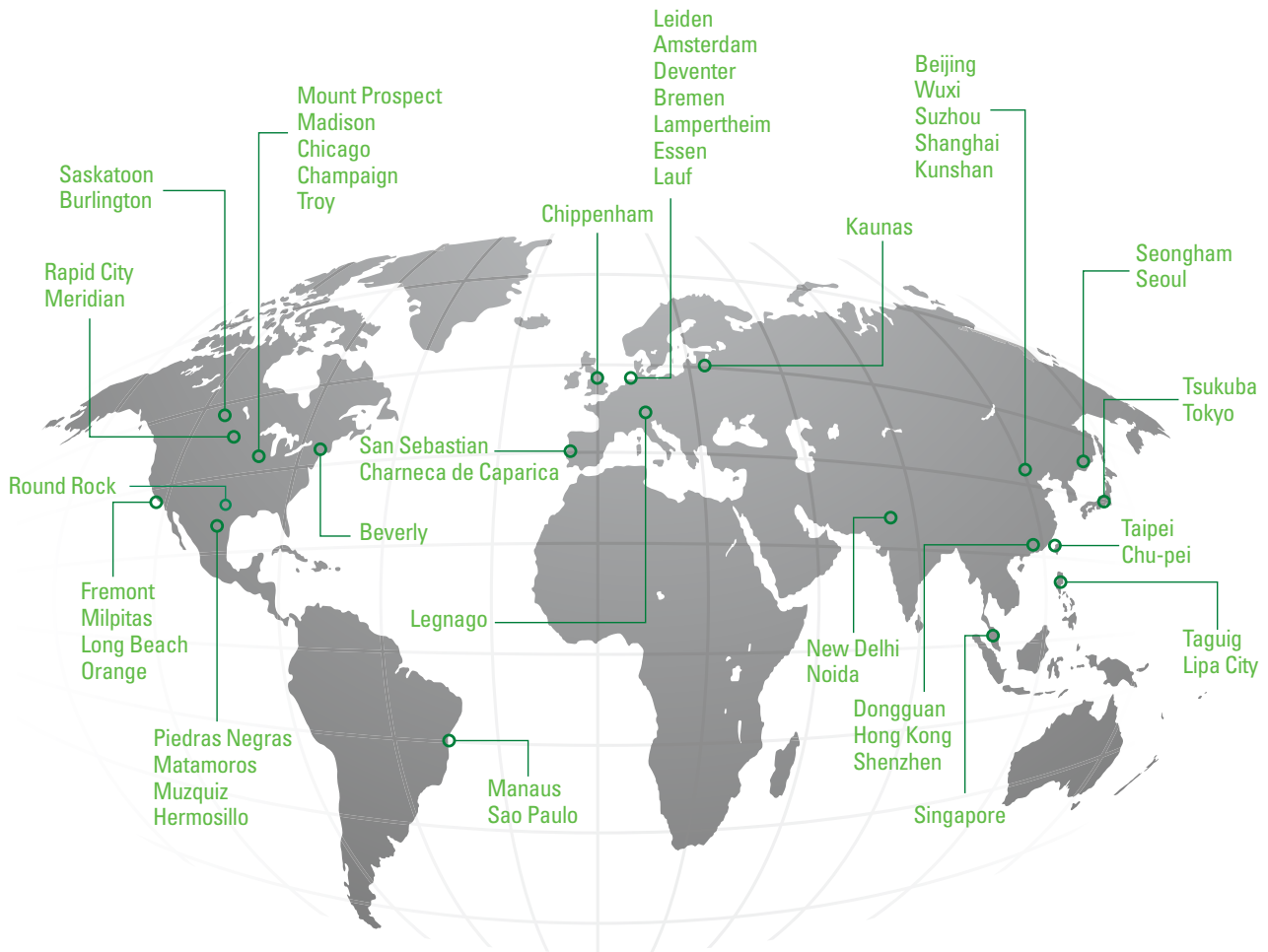
Application and Field Support

Our experienced product and application engineers work step by step with customers from design to installation to determine the best solution. Contact us today: [Littelfuse.com/ContactUs.aspx](https://www.littelfuse.com/ContactUs.aspx)

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LOCAL RESOURCES FOR A GLOBAL MARKET



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Expertise Applied | Answers Delivered