



# EV Charging Solutions-

## Supercharged Solutions to Enhance Safety, Efficiency, and Reliability



EV Infrastructure



**Littelfuse®**

Expertise Applied | Answers Delivered

# Types of electric vehicle charging stations

AC Level 1*	AC Level 2*	DC Fast Charger*	Wireless Charger <sup>‡</sup>
			
<b>Basic home installation</b> (Mode 1 or Mode 2)**	<b>Home and public installation</b> (Mode 3)**	<b>Public and commercial installation</b> (Mode 4)**	<b>Home and public installation</b>
<b>Voltage</b> 120 V AC, 1-phase 250 V AC, 1-phase 480 V AC, 3-phase	<b>Voltage</b> 208 V–240 V AC, 1-phase 250 V AC, 1-phase 480 V AC, 3-phase	<b>Voltage</b> 380 V–600 V AC, 3-phase	<b>Power levels</b> WPT1 – 3.7 kW WPT2 – 7.7 kW WPT3 – 11 kW
<b>Current rating</b> 12 A–16 A (32 A for 3-phase)	<b>Current rating</b> 12 A–80 A	<b>Current rating</b> DC output (up to 400 A)	<b>Grid to battery efficiency</b> 94% at a 10" ground clearance
<b>Charging time</b> 8–12 hours***	<b>Charging time</b> 4–6 hours***	<b>Charging time</b> 30 mins***	<b>Vehicle ground clearance</b> 100–250 mm (3.9" to 9.8")

\* As defined by SAE J1772

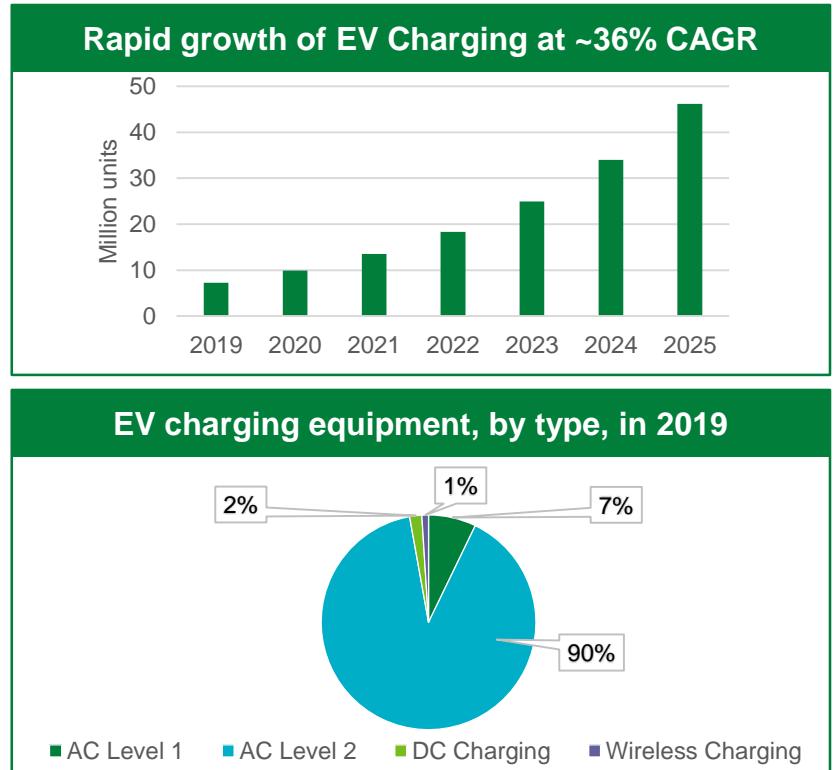
‡ As defined by SAE J2954

\*\* As defined by IEC 61851-1

\*\*\* Charge time dependent on vehicle's battery capacity and charge acceptance rate

# Global electric vehicle charging equipment market

Market trends and drivers
Increasing production of electrified vehicles: estimated 6 million vehicles in 2019 growing to 40 million vehicles in 2025 $\Rightarrow$ need for higher efficiency
7.3 million chargers are active across the world (as of 2019), of which, nearly 6.5 million are private chargers, 0.6 million are public slow chargers, and 0.26 million are public fast chargers
Currently, more than 70% of the charging is done at home. Convenience, cost-efficient, and a variety of support policies are the main driving.
Majority of charging to occur at home or workplace during a span of several hours (AC charging) $\Rightarrow$ bidirectional topologies is needed for smart grid
Limited charging grid capacity in most regions $\Rightarrow$ Emergence of combo ESS+PV with DC charger
Increasing voltage and power output of DC chargers for fast charging $\Rightarrow$ 500 V to 800 V
Low-power DC charging solution in residential/campus will replace the AC charging solution to make charging faster (20 kW DC versus 7 kW AC)
DC charger create a need for improved safety and additional components, such as advanced liquid-cooled cables, substations, and energy storage systems



# AC charging station

## 1 Service Access Panel

- Reed Sensor

## 2 Input Protection

- Fuse
- MOV
- GDT
- TVS Diode

## 3 Auxiliary Power Supply

- PPTC
- Schottky Diode
- SIDACtor® + MOV



## 4 User Interface

- TVS Diode Array
- Polymer ESD Suppressor

## 5 Communication

- TVS Diode Array
- Reed Relay

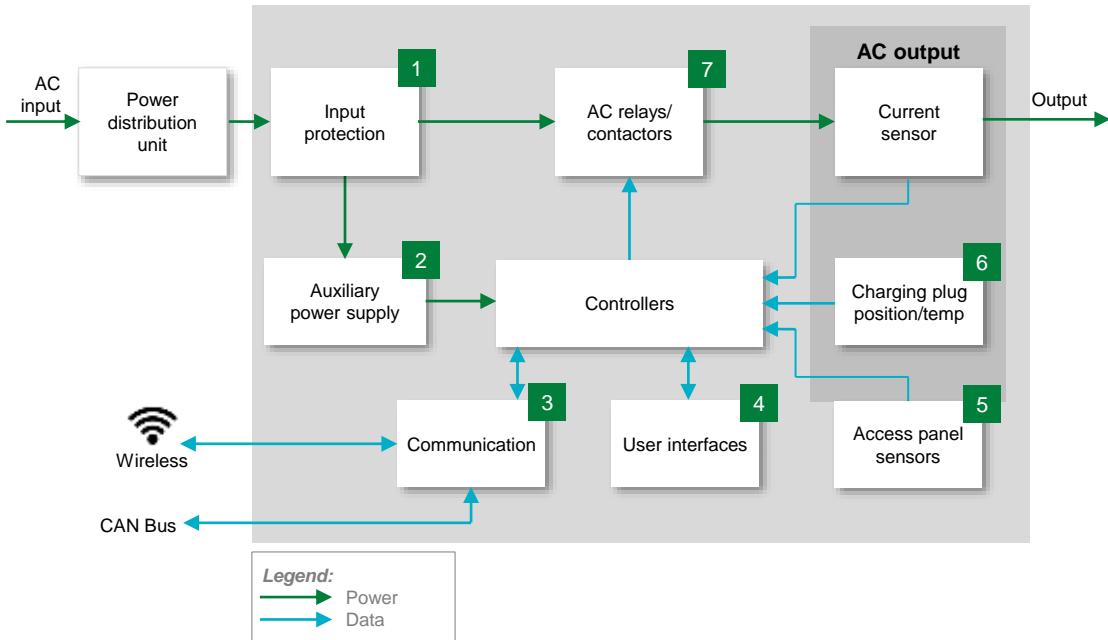
## 6 Charging Plug

- Temperature Sensor
- Reed Sensor

## 7 AC Relays/Contactor

- Contactors & Relays

# AC charger functional block diagram



\*Please contact Littelfuse sales for more details

\*\*Only used in case of Linear transformer

- Note: Other Littelfuse solutions may be suitable depending on design-specific requirements

	Technology	Product
1	High-current Fuse (Primary protection)	<a href="#">606</a>
	Surge protection (Primary protection)	<a href="#">SPD Type 2</a>
	Fast-acting or Time lag Fuse (Secondary protection)	<a href="#">314</a> , <a href="#">324</a> , <a href="#">215</a>
	Metal-Oxide Varistor	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>
	Gas Discharge Tube	<a href="#">CG2</a> , <a href="#">CG3</a>
	TVS Diode	<a href="#">AK6</a> , <a href="#">1.5SMC</a>
	PPTC	<a href="#">LVR**</a>
2	Schottky Diode	<a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>
3	SIDACtor + MOV	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>
4	TVS Diode Array	<a href="#">AQ24CAN</a> , <a href="#">SM712</a>
5	Reed Relay	<a href="#">HE3600</a>
6	TVS Diode Array Polymer ESD	<a href="#">SP1026</a> <a href="#">XGD10402</a>
7	Reed Sensor	<a href="#">59060</a> , <a href="#">59045</a>
7	Temperature Sensor	<a href="#">PPG</a> , <a href="#">USW</a> , Glass Coated Thermistor
	Reed Sensor	<a href="#">59060</a> , <a href="#">59045</a>
7	Contactors or Relays	<a href="#">HCC 1 &amp; 2 Pole</a> , <a href="#">HCC 3 &amp; 4 Pole</a> , <a href="#">HCD</a> , or <a href="#">SCO1*</a> , <a href="#">SCO2*</a>



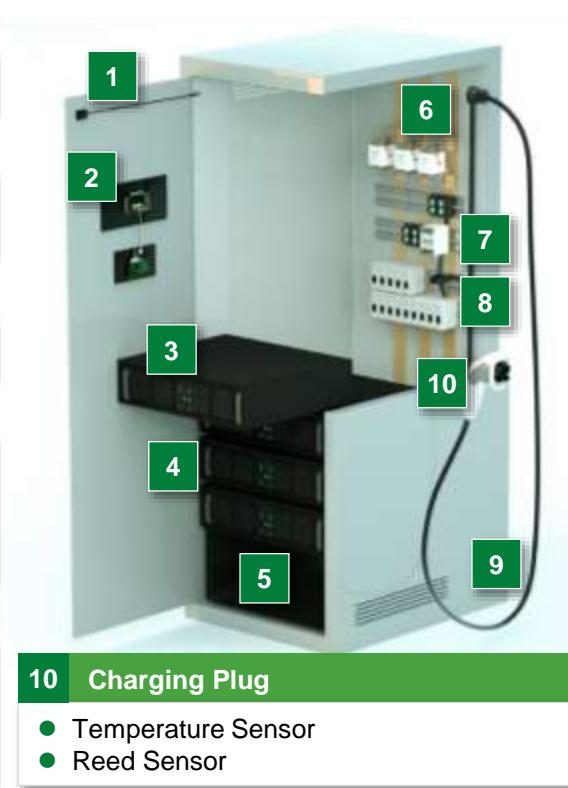
Click on the product series in  
the table below for more info

# Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	High-current Fuse (Primary Protection)	Primary over-current protection of EV equipment	<a href="#">606</a>	Enables robust yet compact design; can operate in extreme temperature environment	Rated voltage @ 500 VAC; 40–63 A rating available; small footprint
	Surge protection (Primary protection)	Protects from power fluctuations or surges	<a href="#">SPD Type 2</a>	Withstands high-energy transients to prevent disruption, downtime, and degradation	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
	Fast-acting Fuse (Secondary Protection)	Overcurrent protection of auxiliary power supply	<a href="#">314</a> , <a href="#">324</a> , <a href="#">215</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	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	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	High energy absorption capability: 40–530 J (2 ms); integrated thermal protection
	GDT		<a href="#">CG2</a> , <a href="#">CG3</a>	Small form-factor allows for compact system design	High energy absorption capability; small form-factor; low leakage current
	TVS Diode	Protects power line from transient surge transient	<a href="#">AK6</a> , <a href="#">1.5SMC</a>	Good clamping and fast response time for high-energy transient protection	High power TVS 8/20 $\mu$ s rating from 1–20 kA in axial-lead or SMT form factor
2	PPTC	Protected linear transformers from damages due to mech overloads, overheating, etc.	<a href="#">LVR</a>	Fast time to trip; offers boards space savings; reduces customer qual time by complying with UL/IEC	Line voltage ratings of 120 and 240 VAC; low resistance; holding current up to 2 A; compact size
	Schottky Diode	Used for rectification	<a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>	Reduces switching losses; increases system efficiency, reliability and thermal management	High surge capability; negligible reverse recovery current; $T_J = 175^\circ\text{C}$
	SIDACtor + MOV	Enhancing surge protection for auxiliary power supply	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>	Good clamping and fast response time for high-energy transient protection	3 kA, 8/20 $\mu$ s surge capability to help protect AC lines from harmful transient surges.
3	TVS Diode Array	Protects CAN, Ethernet, RS-485 bus from ESD, EFT, and voltage transient	<a href="#">AQ24CAN</a> , <a href="#">SM712</a>	Ensures reliability of the equipment without performance degradation	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	<a href="#">HE3600</a>	Low power consumption; galvanic isolation; immune to environmental effects	Miniature single in-line package; external magnetic shield option
4	TVS Diode Array Polymer ESD	Protects ICs from ESD through display	<a href="#">SP1026</a> , <a href="#">XGD10402</a>	Smaller form-factor and multi-line protection enables ease of design	SP1026 has high ESD robustness for touchpads; XGD10402 has ultra-low capacitance for I/O
5	Reed Sensor	Access panel for position sensing	<a href="#">59060</a> , <a href="#">59045</a>	Robust in end application; mount directly into PCB; no standby power requirement	Well suited for usage in high-moisture and contaminated environments; molded stand-off to allow board washing
6	Temperature Sensor	DC contacts hotspot detection	<a href="#">PPG</a> , <a href="#">USW</a> , <a href="#">Glass Coated Thermistor</a>	Offers high accuracy; high reliability; excellent stability at high temperatures	Linear relationship between temp and resistance; temp range $-50^\circ\text{C}$ to $+500^\circ\text{C}$
	Reed Sensor	Charging plug position sensing	<a href="#">59060</a> , <a href="#">59045</a>	Robust design; well suited for usage in high-moisture and contaminated environment	Hermetically sealed, magnetically operated contacts; certified for use in NA and Europe
7	Contactors or Relays	Safety cutoff on the grid (power network) to prevent abnormal current supply.	<a href="#">HCC 1 &amp; 2 Pole</a> , <a href="#">HCC 3 &amp; 4 Pole</a> , <a href="#">HCD</a>	Predetermined life cycle for application to minimize cost; high electrical and thermal conductivity; good resistance to oxidation for longer life	Long electrical life; High surge capability; Certified for use in North America, Europe and Asia
			<a href="#">SCO1</a> , <a href="#">SCO2</a>	PCB mount capable; higher flexibility for designers; compact design;	Low heat generation and low coil power consumption; performance to meet regulatory UL/IEC compliance

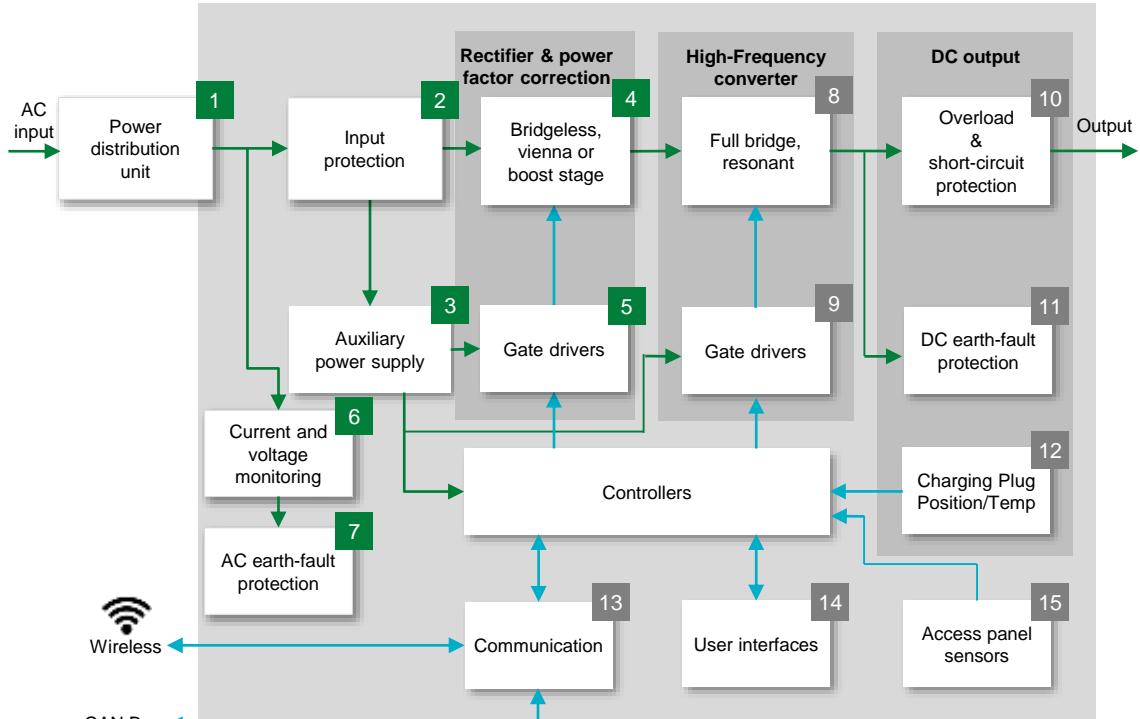
# DC charging station

<b>1</b>	Service Access Panel
	<ul style="list-style-type: none"><li>● Reed Sensor</li></ul>
<b>2</b>	User Interface
	<ul style="list-style-type: none"><li>● TVS Diode Array</li><li>● Polymer ESD Suppressor</li></ul>
<b>3</b>	Communication
	<ul style="list-style-type: none"><li>● TVS Diode Array</li></ul>
<b>4</b>	Rectification & PFC
	<ul style="list-style-type: none"><li>● SiC/Si MOSFET</li><li>● Rectifier Diode/Module</li><li>● Gate Driver</li><li>● Temperature Sensor</li></ul>
<b>5</b>	Rectification & PFC
	<ul style="list-style-type: none"><li>● SiC/Si MOSFET</li><li>● Rectifier Diode/Module</li><li>● Gate Driver</li><li>● Temperature Sensor</li></ul>



<b>6</b>	Power Distribution Unit
	<ul style="list-style-type: none"><li>● Fuse</li></ul>
<b>7</b>	Input Protection
	<ul style="list-style-type: none"><li>● Fuse</li><li>● Surge Protection Device</li><li>● TVS Diode</li><li>● Current Transformer</li><li>● AC Earth Fault Relay</li></ul>
<b>8</b>	DC Output Protection
	<ul style="list-style-type: none"><li>● DC Fuse</li><li>● HVDC Contactor</li><li>● Earth Fault Relay</li></ul>
<b>9</b>	Auxiliary Power Supply
	<ul style="list-style-type: none"><li>● Fuse</li><li>● MOV, GDT, SIDACtor® + MOV</li><li>● Si MOSFET</li><li>● Rectifier Diode</li></ul>

# DC charger functional block diagram



**Legend:**  
 Power  
 Data

	Technology	Product
1	AC Fuse (PDU level)	<a href="#">JLLS</a> , <a href="#">JLLN</a>
2	Overcurrent protection (Primary protection)	<a href="#">PSR</a> , <a href="#">L50QS</a> , <a href="#">L75QS</a>
	Surge protection (Primary protection)	<a href="#">SPD Type 2</a>
	TVS Diode	<a href="#">AK6</a> , <a href="#">1.5SMC</a>
	Si MOSFET	<a href="#">Polar™</a>
3	Rectifier and Schottky Diode	<a href="#">DMA</a> , <a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>
	AC Fuse (Secondary protection)	<a href="#">314</a> , <a href="#">324</a>
	Metal-Oxide Varistor	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>
	Gas Discharge Tube	<a href="#">CG2</a> , <a href="#">CG3</a>
	SIDACtor + MOV	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>
	Rectifier Diode	<a href="#">DMA</a>
	Rectifier Module	<a href="#">MDD</a> , <a href="#">VUO</a> , <a href="#">MDNA</a>
4	SiC/Si MOSFET/Discrete IGBT	<a href="#">LSIC1MO</a> / <a href="#">X2-Class</a> / <a href="#">XPT</a>
	Diode	<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>
	Temperature Sensor	<a href="#">USUR1000</a> , <a href="#">KC</a>
5	Gate Driver	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>
6	Current Transformer	<a href="#">SE-CS30</a>
7	AC Earth-Fault Relay	<a href="#">SE-704</a>

**Note:** Other Littelfuse solutions may be suitable depending on design-specific requirements.

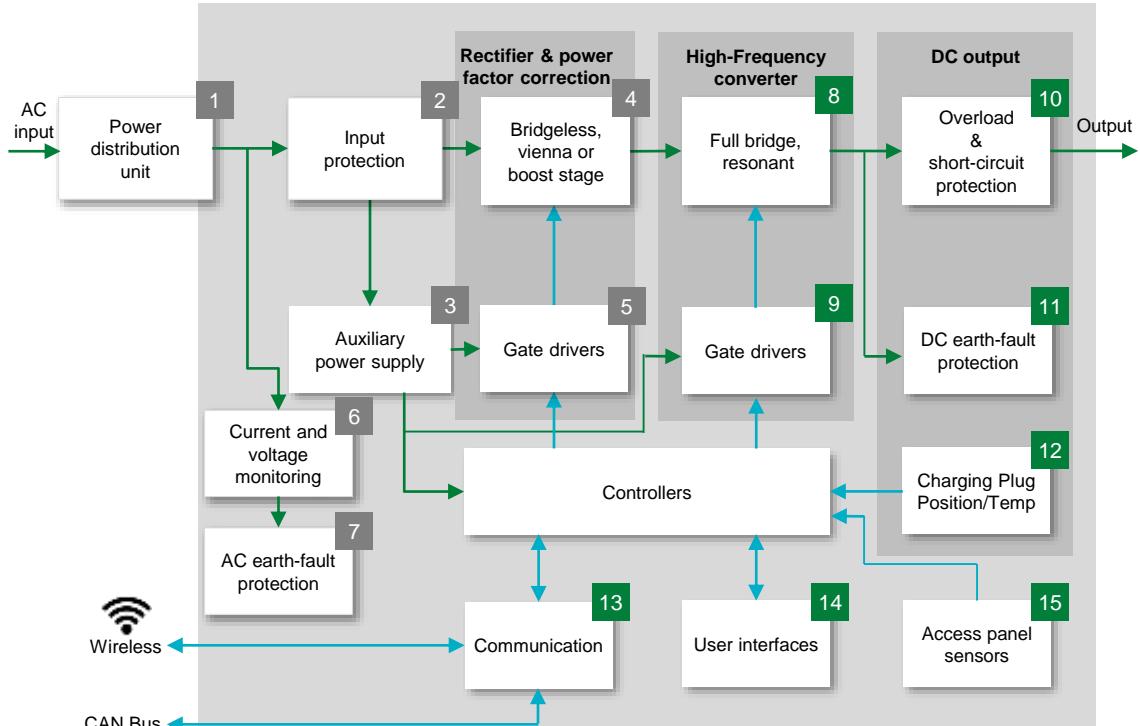


Click on the product series in  
the table below for more info

# Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	AC Fuse (PDU Level)	Provide fast-acting overload and short circuit protection.	<a href="#">JLLS</a> , <a href="#">JLLN</a>	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents;	Extremely current-limiting; Small footprint 200 kA interrupting rating
2	Overcurrent protection (Primary protection)	Protects semiconductor devices	<a href="#">PSR</a> , <a href="#">L50QS</a> , <a href="#">L75QS</a>	Lower $I^2t$ performance allows for quick response to protect devices from higher heat energy	550–1300 V <sub>AC</sub> , 500–1000 V <sub>DC</sub> , 40–2000 A
	Surge protection (Primary protection)	Protects from power fluctuations or surges	<a href="#">SPD Type 2</a>	Withstands high-energy transients to prevent disruption, downtime, and degradation	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
	TVS Diode	Protects power line from transient surge transient	<a href="#">AK6</a> , <a href="#">1.5SMC</a>	Good clamping and fast response time for high-energy transient protection	High power TVS 8/20 $\mu$ s rating from 1 kA to 20 kA in axial-lead or SMT form factor
3	Si MOSFET	High-speed switching	<a href="#">Polar™</a>	Easy to mount; space-savings; high power density	Low $R_{DS(on)}$ and $Q_g$ ; avalanche rated; international standard packages; low package inductance
	Rectifier and Schottky Diode	Provides output rectification in auxiliary power supply	<a href="#">DMA</a> , <a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>	Improves power supply unit efficiency	Low forward voltage drop; high-frequency operation; high junction temperature
	AC Fuse (Secondary protection)	Overcurrent protection of auxiliary power supply	<a href="#">314</a> , <a href="#">324</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	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	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	High energy absorption capability; 40–530 J (2 ms); integrated thermal protection
	GDT		<a href="#">CG2</a> , <a href="#">CG3</a>	Small form-factor allows for compact system design	High energy absorption capability; small form-factor; low leakage current
	SIDACtor + MOV	Enhancing surge protection for auxiliary power supply	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>	Good clamping and fast response time for high-energy transient protection	3 kA, 8/20 $\mu$ s surge capability to help protect AC lines from harmful transient surges.
4	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	<a href="#">DMA</a>	Small footprint; multiple package options (high voltage, isolated, and standard packages)	Low leakage current and forward voltage drop; improved thermal behavior; high robustness
	Rectifier Module		<a href="#">MDD</a> , <a href="#">VUO</a> , <a href="#">MDNA</a>	Compact design, better electrical isolations	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	<a href="#">LSIC1MO/X2-Class/XPT</a>	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Diode		<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>	Reduces switching losses; increases efficiency	High surge capability; negligible $I_{RR}$ ; $T_j$ 175 °C
5	Temperature Sensor	Temp sensing for semiconductors	<a href="#">USUR1000</a> , <a href="#">KC</a>	Rapid thermal response and long-time reliability	UL recognized; temperature range: -40–125 °C
6	Gate Driver	Controls the switching MOSFETs/IGBTs	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>	Quick turn-on and turn-off of MOSFETs/IGBTs; eliminates the need for separate supply	9 A peak current; low propagation delay time; low output impedance
7	Current Transformer	Offers ground-fault detection and protection	<a href="#">SE-CS30</a>	Specifically designed for low level detection; flux conditioner is included to prevent saturation	Turns ratio 600:1 and current rating 30:0.05 A
7	AC Earth-Fault Relay		<a href="#">SE-704</a>	No calibration; low level protection and system coordination; low maintenance	Microprocessor-based; adjustable pickup (10 mA-5 A); Adjustable time delay (30 ms–2 s)

# DC charger functional block diagram



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

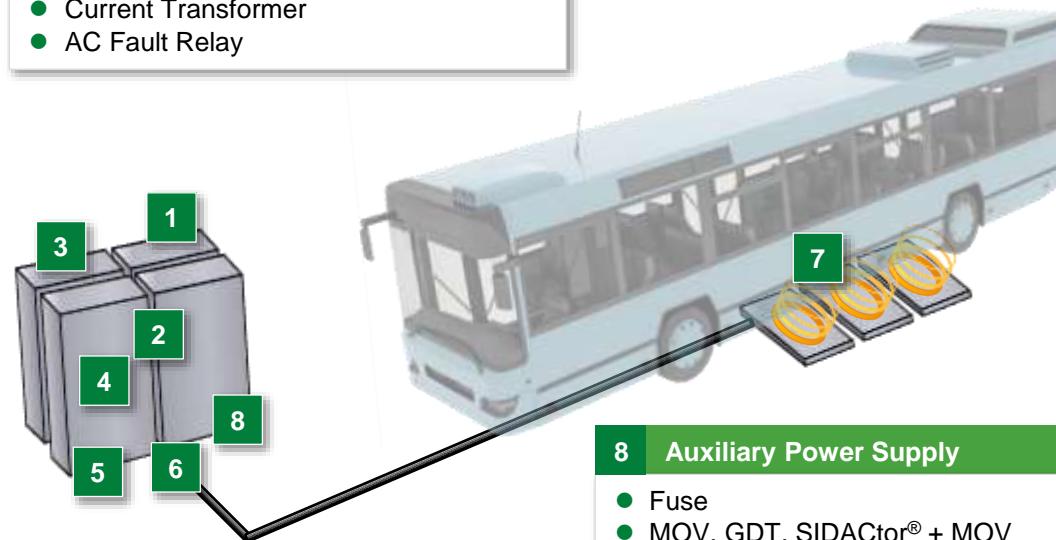


Click on the product series in  
the table below for more info

# Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
8	SiC or Si MOSFET	High-frequency switching and rectification	<a href="#">LSIC1MO</a> , <a href="#">X-Class</a> , <a href="#">X2-Class</a> , <a href="#">HiPerFET™</a>	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Diode		<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>	Reduces switching losses; increases efficiency	High surge capability; negligible $I_{RR}$ ; $T_j$ 175 °C
	Temperature Sensor	Semiconductor temperature measurement	<a href="#">USUR1000</a> , <a href="#">KC</a>	Rapid thermal response and long-time reliability	UL recognized; wide range of temperature: -40 °C to 125 °C
9	Gate Driver	Controls the switching MOSFETs	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>	Quick turn-on and turn-off of MOSFETs; eliminates the need for separate supply	9 A peak current; low propagation delay time; low output impedance
10	DC Fuse	Protects semiconductor devices	<a href="#">PSR</a> , <a href="#">SFPJ</a>	Lower $I^2t$ performance allows for quick response to protect devices from higher heat energy	550–1300 $V_{AC}$ , 500–1000 $V_{DC}$ , 40–2000 A
	Diode	CHAdMO standard requires safety diode for secondary protection	<a href="#">DMA</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>	Compact design; low turn-on loss; lower power dissipation	High voltage options; very low forward voltage drop; small form factor
	HV DC Contactors	The main contactors connect and disconnect the DC charging unit	<a href="#">DCNxx</a>	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
11	DC Earth-Fault Relay	Offers low-level ground-fault protection. Ground-fault current is sensed using a Ground-Reference Module	<a href="#">SE-601</a>	Provides a wide range of low-level protection; adjustable trip delay allows quick protection or delayed response	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		<a href="#">SE-GRM</a>		
12	Temperature Sensor	DC contacts hotspot detection	<a href="#">PPG</a> , <a href="#">USW</a> , <a href="#">Glass Coated Thermistor</a>	Offers high accuracy; high reliability; excellent stability at high temperature	Linear relationship between temp and resistance; temp range -50 °C to +500 °C
	Reed Sensor	Charging plug position sensing	<a href="#">59060</a> , <a href="#">59045</a>	Robust design; well suited for usage in high-moisture and contaminated environment	Hermetically sealed, magnetically operated contacts. Certified for use in NA and Europe
13	TVS Diode Array	Protects CAN, Ethernet, RS-485 bus from ESD, EFT, and voltage transient	<a href="#">AQ24CAN</a> , <a href="#">SM712</a>	Ensures reliability of the equipment without performance degradation	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	<a href="#">SP1026</a> , <a href="#">XGD10402</a>	Smaller form-factor and multi-line protection enables ease of design	Low capacitance of 1.0 pF per I/O
15	Reed Sensor	Access panel for position sensing	<a href="#">59060</a> , <a href="#">59045</a>	Robust design; well-suited for usage in high-moisture and contaminated environment	Hermetically sealed; magnetically operated contacts; certified for use in NA and Europe

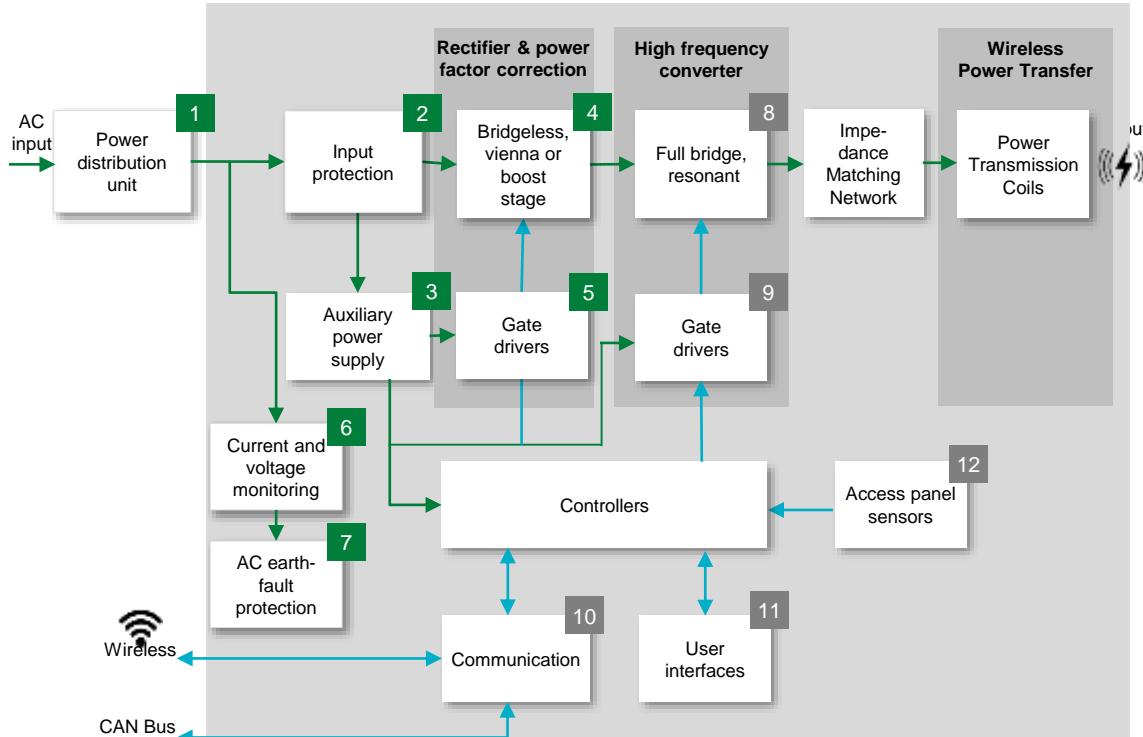
# Wireless charging station

<b>1</b> Service Access Panel	<b>6</b> Input Protection	<b>7</b> Power Distribution Unit
<ul style="list-style-type: none"><li>Reed Sensor</li></ul>	<ul style="list-style-type: none"><li>Fuse</li><li>Surge Protection Device</li><li>TVS Diode</li><li>Current Transformer</li><li>AC Fault Relay</li></ul>	<ul style="list-style-type: none"><li>Fuse</li></ul>
<b>2</b> User Interface		
<ul style="list-style-type: none"><li>TVS Diode Array</li><li>Polymer ESD Suppressor</li></ul>		
<b>3</b> Communication		
<ul style="list-style-type: none"><li>TVS Diode Array</li></ul>		
<b>4</b> Rectification & PFC		
<ul style="list-style-type: none"><li>SiC/Si MOSFET</li><li>Rectifier Diode/Module</li><li>Gate Driver</li><li>Temperature Sensor</li></ul>		
<b>5</b> High-frequency Converter		
<ul style="list-style-type: none"><li>SiC MOSFET</li><li>Gate Driver</li><li>Temperature Sensor</li></ul>		
		<b>8</b> Auxiliary Power Supply
		<ul style="list-style-type: none"><li>Fuse</li><li>MOV, GDT, SIDACtor® + MOV</li><li>Si MOSFET</li><li>Rectifier Diode</li></ul>



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

# Wireless Charger Functional Block Diagram



Legend:  
→ Power  
→ Data

	Technology	Product
1	AC Fuse (PDU level)	<a href="#">JLLS</a> , <a href="#">JLLN</a>
	Overcurrent protection (Primary protection)	<a href="#">PSR</a> , <a href="#">L50QS</a> , <a href="#">L75QS</a>
2	Surge protection (Primary protection)	<a href="#">SPD Type 2</a>
	TVS Diode	<a href="#">AK6</a> , <a href="#">1.5SMC</a>
	Si MOSFET	<a href="#">Polar™</a>
3	Rectifier and Schottky Diode	<a href="#">DMA</a> , <a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>
	AC Fuse (Secondary protection)	<a href="#">314</a> , <a href="#">324</a>
	Metal-Oxide Varistor	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>
	Gas Discharge Tube	<a href="#">CG2</a> , <a href="#">CG3</a>
	SIDACtor + MOV	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>
4	Rectifier Diode	<a href="#">DMA</a>
	Rectifier Module	<a href="#">MDD</a> , <a href="#">VUO</a> , <a href="#">MDNA</a>
	SiC/Si MOSFET/Discrete IGBT	<a href="#">LSIC1MO</a> / <a href="#">X2-Class</a> / <a href="#">XPT</a>
	Diode	<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>
	Temperature Sensor	<a href="#">USUR1000</a> , <a href="#">KC</a>
5	Gate Driver	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>
6	Current Transformer	<a href="#">SE-CS30</a>
7	AC Earth-Fault Relay	<a href="#">SE-704</a>

**Note:** Other Littelfuse solutions may be suitable depending on design-specific requirements.

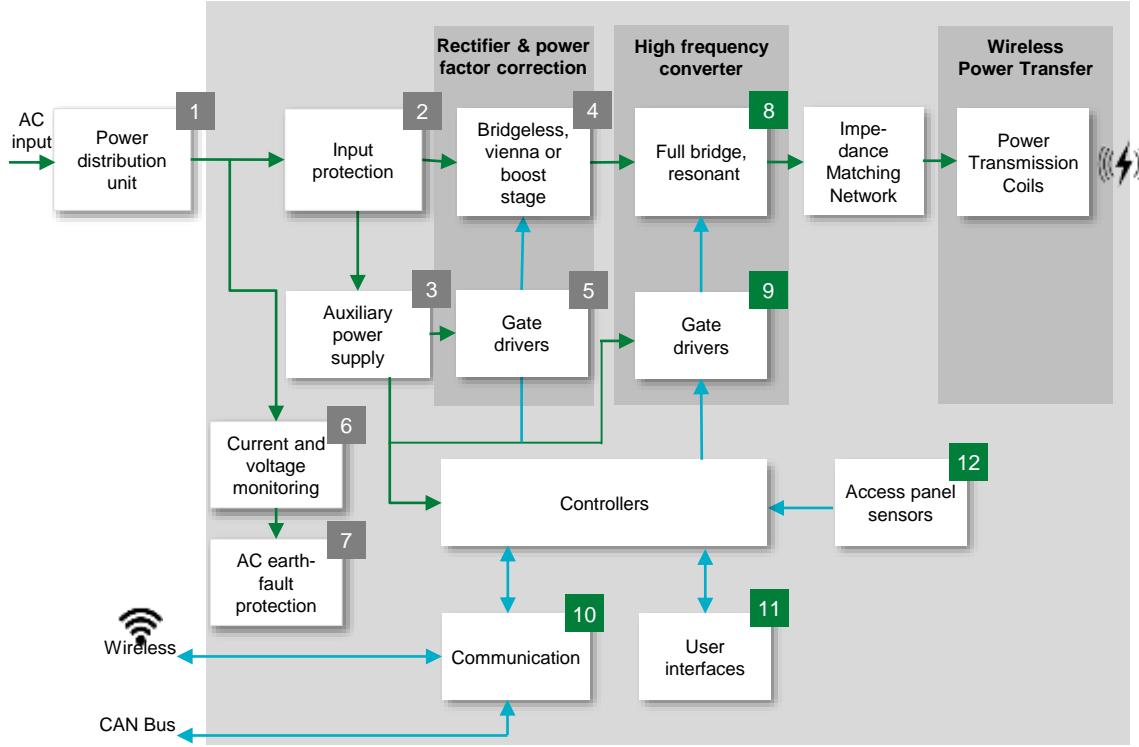


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the table below for more info

# Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	AC Fuse (PDU Level)	Provide fast-acting overload and short circuit protection.	<a href="#">JLLS</a> , <a href="#">JLLN</a>	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents;	Extremely current-limiting; Small footprint 200 kA interrupting rating
2	Overcurrent protection (Primary protection)	Protects semiconductor devices	<a href="#">PSR</a> , <a href="#">L50QS</a> , <a href="#">L75QS</a>	Lower $I^2t$ performance allows for quick response to protect devices from higher heat energy	550–1300 V <sub>AC</sub> , 500–1000 V <sub>DC</sub> , 40–2000 A
	Surge protection (Primary protection)	Protects from power fluctuations or surges	<a href="#">SPD Type 2</a>	Withstands high-energy transients to prevent disruption, downtime, and degradation	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
	TVS Diode	Protects power line from transient surge transient	<a href="#">AK6</a> , <a href="#">1.5SMC</a>	Good clamping and fast response time for high-energy transient protection	High power TVS 8/20 $\mu$ s rating from 1 kA to 20 kA in axial-lead or SMT form factor
3	Si MOSFET	High-speed switching	<a href="#">Polar™</a>	Easy to mount; space-savings; high power density	Low $R_{DS(on)}$ and $Q_g$ ; avalanche rated; international standard packages; low package inductance
	Rectifier and Schottky Diode	Provides output rectification in auxiliary power supply	<a href="#">DMA</a> , <a href="#">DST</a> , <a href="#">DSA</a> , <a href="#">DSB</a>	Improves power supply unit efficiency	Low forward voltage drop; high-frequency operation; high junction temperature
	AC Fuse (Secondary protection)	Overcurrent protection of auxiliary power supply	<a href="#">314</a> , <a href="#">324</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	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	<a href="#">TMOV</a> , <a href="#">UltraMOV</a>	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	High energy absorption capability; 40–530 J (2 ms); integrated thermal protection
	GDT		<a href="#">CG2</a> , <a href="#">CG3</a>	Small form-factor allows for compact system design	High energy absorption capability; small form-factor; low leakage current
	SIDACtor + MOV	Enhancing surge protection for auxiliary power supply	<a href="#">Pxxx0FNL</a> + <a href="#">UltraMOV</a>	Good clamping and fast response time for high-energy transient protection	3 kA, 8/20 $\mu$ s surge capability to help protect AC lines from harmful transient surges.
4	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	<a href="#">DMA</a>	Small footprint; multiple package options (high voltage, isolated, and standard packages)	Low leakage current and forward voltage drop; improved thermal behavior; high robustness
	Rectifier Module		<a href="#">MDD</a> , <a href="#">VUO</a> , <a href="#">MDNA</a>	Compact design, better electrical isolations	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	<a href="#">LSIC1MO/X2-Class/XPT</a>	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Diode		<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a>	Reduces switching losses; increases efficiency	High surge capability; negligible $I_{RR}$ ; $T_j$ 175 °C
5	Temperature Sensor	Temp sensing for semiconductors	<a href="#">USUR1000</a> , <a href="#">KC</a>	Rapid thermal response and long-time reliability	UL recognized; temperature range: -40–125 °C
6	Gate Driver	Controls the switching MOSFETs/IGBTs	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>	Quick turn-on and turn-off of MOSFETs/IGBTs; eliminates the need for separate supply	9 A peak current; low propagation delay time; low output impedance
6	Current Transformer	Offers ground-fault detection and protection	<a href="#">SE-CS30</a>	Specifically designed for low level detection; flux conditioner is included to prevent saturation	Turns ratio 600:1 and current rating 30:0.05 A
7	AC Earth-Fault Relay		<a href="#">SE-704</a>	No calibration; low level protection and system coordination; low maintenance	Microprocessor-based; adjustable pickup (10 mA-5 A); Adjustable time delay (30 ms–2 s)

# Wireless Charger Functional Block Diagram



	Technology	Product
8	SiC MOSFET	<a href="#">LSIC1MO</a>
9	Temperature Sensor	<a href="#">USUR1000, KC</a>
10	Gate Driver	<a href="#">IXDN609, IX4351NE</a>
11	TVS Diode Array	<a href="#">AQ24CAN, SM712</a>
12	TVS Diode Array Polymer ESD	<a href="#">SP1026</a> <a href="#">XGD10402</a>
12	Reed Switch	<a href="#">59060, 59045</a>

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



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

# Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
8	SiC MOSFET	High-frequency switching and rectification	<a href="#">LSIC1MO</a>	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Temperature Sensor	Semiconductor Temperature measurement	<a href="#">USUR1000</a> , <a href="#">KC</a>	Rapid thermal response and long-time reliability	UL recognized; wide range of temperature: -40 °C to 125 °C
9	Gate Driver	Controls the switching MOSFETs/IGBTs	<a href="#">IXDN609</a> , <a href="#">IX4351NE</a>	Quick turn-on and turn-off of MOSFETs/IGBTs; eliminates the need for separate supply	9 A peak current; low propagation delay time; low output impedance
10	TVS Diode Array	Protects CAN, Ethernet, RS-485 bus from ESD, EFT, and voltage transient	<a href="#">AQ24CAN</a> , <a href="#">SM712</a>	Ensures reliability of the equipment without performance degradation	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	<a href="#">SP1026</a> <a href="#">XGD10402</a>	Smaller form-factor and multi-line protection enables ease of design	Low capacitance of 1.0 pF per I/O
12	Reed Switch	Charging plug position sensing	<a href="#">59060</a> , <a href="#">59045</a>	Robust design; well suited for usage in high-moisture and contaminated environment	Hermetically sealed; magnetically operated contacts; certified for use in NA and Europe

# Select standards for EV charging equipment

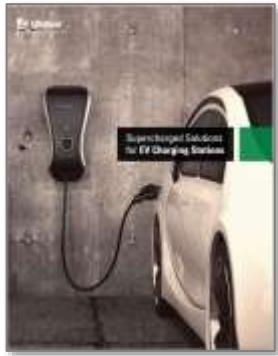
Standard	Title	General Scope	Region
IEC 61851 Series	Electric Vehicle Conductive Charging System	Various parts of this standard cover general requirements, along with AC chargers and DC chargers specifically.	Global
IEC 62196 Series	Plugs, Socket-Outlets, Vehicle Connectors and Vehicle Inlets - Conductive Charging of Electric Vehicles	Standards for charging plugs, sockets, and connectors.	Global
IEC 61980 Series	Electric Vehicle Wireless Power Transfer (WPT) Systems	Various parts of this standard cover general requirements for wireless charging systems, along with specific technology-based requirements.	Global
GB/T 18487 Series	Electric Vehicle Conductive Charging System	Various parts of this standard cover general requirements, along with AC chargers and DC chargers specifically.	China
GB/T 20234 Series	Connection Set for Conductive Charging of Electric Vehicles	Standards for charging plugs in China.	China
SAE J1772*	Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler	Physical, electrical, functional and performance standard for charging plugs in North America.	North America
SAE J2954*	Wireless Power Transfer for Light-Duty Plug-In/Electric Vehicles and Alignment Methodology	Interoperability, electromagnetic compatibility, EMF, minimum performance, safety and testing for wireless chargers in North America.	North America
UL 2594	Standard for Electric Vehicle Supply Equipment	Safety standard for supply equipment (charging stations, cord sets, power outlets, etc.) in North America. Tri-national standard for U.S., Canada, and Mexico (known as CAN/CSA C22.2 No. 280 in Canada and NMX-J-677-ANCE in Mexico).	North America
UL 2202	Standard for Electric Vehicle (EV) Charging System Equipment	Safety standard for electric vehicle charging equipment	U.S.

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# Additional information can be found on [Littelfuse.com](http://electronicscatalogs.littelfuse.com/)

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EV Charging Brochure



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Circuit Protection Catalog



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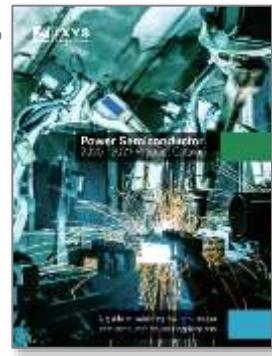
Sensor Selection Guide



Industrial Fuses Catalog



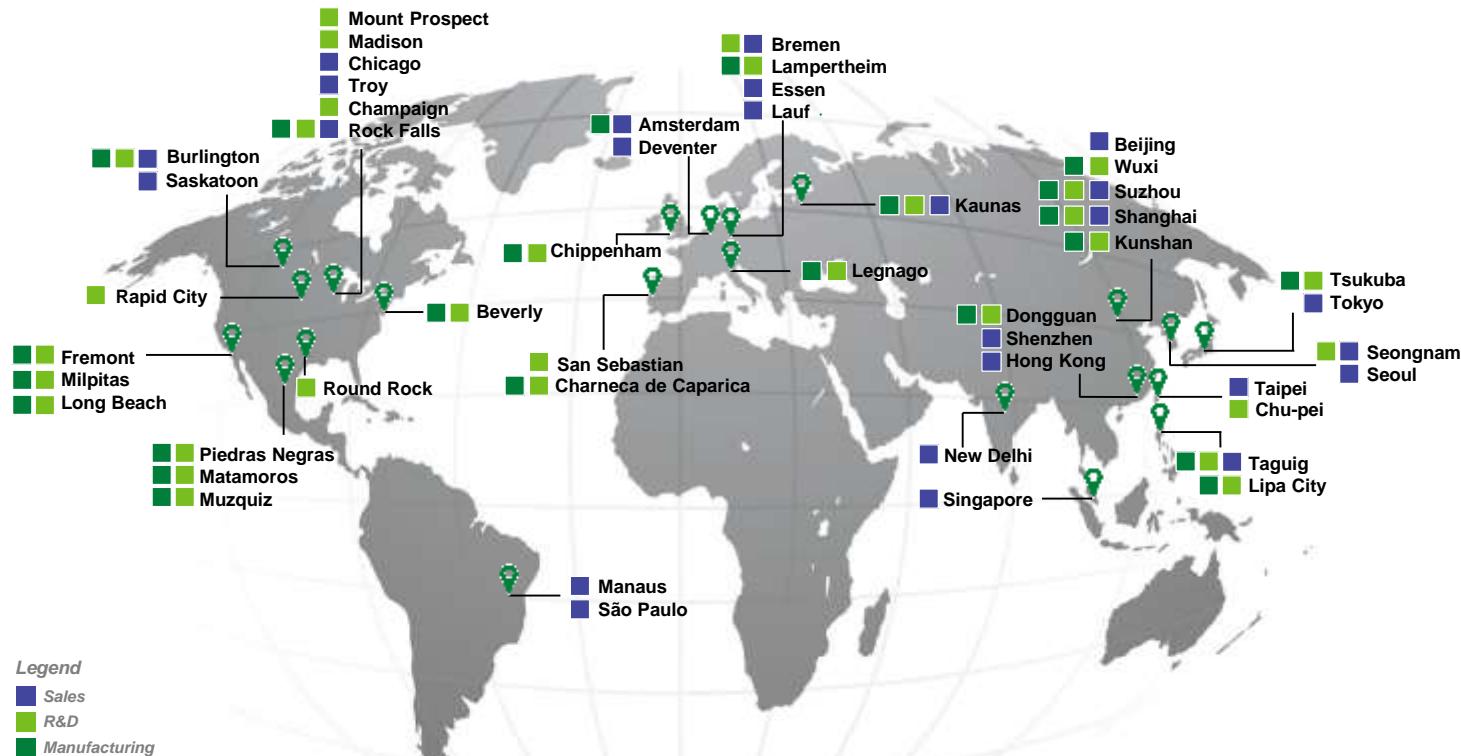
Power Semiconductor Catalog



Power Relay & Control Catalog



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Supplementary slide

# Types of electric vehicle charging stations

■ As defined by SAE J1772  
■ As defined by IEC 61851-1



## AC Level 1

- 120V AC, 1-phase, 12 A or 16 A max. continuous current



## AC Level 2

- 208 V-240 V AC, 1-phase, ≤ 80 A max. continuous current



## DC Fast Charger

- 380 V-600 V AC, 3-phase input; DC output

### Mode 1 (AC)

- 250 V AC, 1-phase, 16 A max. -OR- 480 V AC, 3-phase, 16 A max.
- Cord with no pilot or auxiliary connections

### Mode 2 (AC)

- 250 V AC, 1-phase, 32 A max. -OR- 480 V AC, 3-phase, 32 A max.
- Cord with control pilot & shock protection

### Mode 3 (AC)

- 250V AC, 1-phase, 32A max. -OR- 480 V AC, 3-phase, 32 A max.
- Permanently connected to AC supply with control pilot & shock protection

### Mode 4 (DC)

- AC or DC input supply, cord or permanently connected, with control pilot & shock protection

- Delivers AC power from the wall socket to vehicle's on-board charger
- Typically takes 8-12 hours\* to charge fully depleted battery

- Delivers AC power from the electrical supply to vehicle's on-board charger
- Typically takes 4-6 hours\* to charge fully depleted battery

- Delivers DC power, bypassing the vehicle's on-board charger
- Typically provides 80% charge of fully depleted battery within 30 minutes\*

\* Charge time dependent on vehicle's battery capacity and charge acceptance rate