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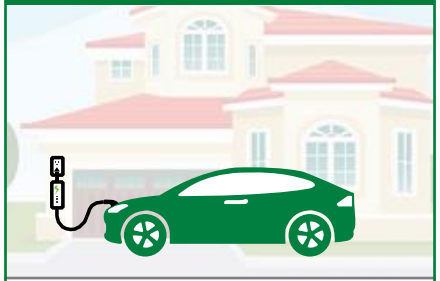
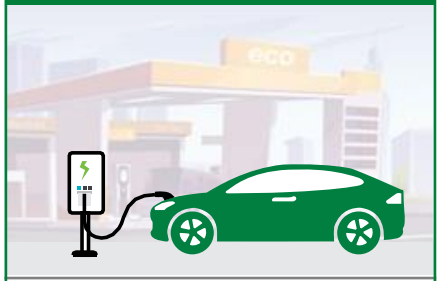
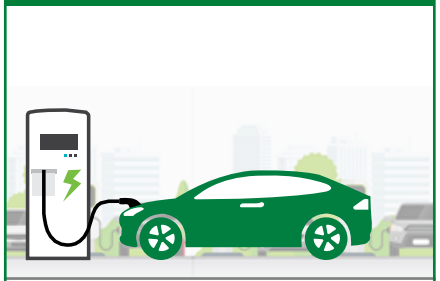
EV Charging Solutions

EV Infrastructure

REV0222

Types of electric vehicle charging stations

AC Level 1*	AC Level 2*	DC Fast Charger*	Wireless Charger‡
			
Basic home installation (Mode 1 or Mode 2)**	**Home and public installation** (Mode 3)**	**Public and commercial installation** (Mode 4)**	**Home and public installation**
Voltage 120 V AC, 1-phase 250 V AC, 1-phase 480 V AC, 3-phase	**Voltage** 208 V–240 V AC, 1-phase 250 V AC, 1-phase 480 V AC, 3-phase	**Voltage** 380 V–600 V AC, 3-phase	**Power levels** WPT1 − 3.7 kW WPT2 − 7.7 kW WPT3 − 11 kW
Current rating 12 A–16 A (32 A for 3-phase)	**Current rating** 12 A–80 A	**Current rating** DC output (up to 400 A)	**Grid-to-battery efficiency** 94% at a 10″ ground clearance
Charging time 8–12 hours***	**Charging time** 4–6 hours***	**Charging time** 15–30 mins***	**Vehicle ground clearance** 100−250 mm (3.9″ to 9.8″)

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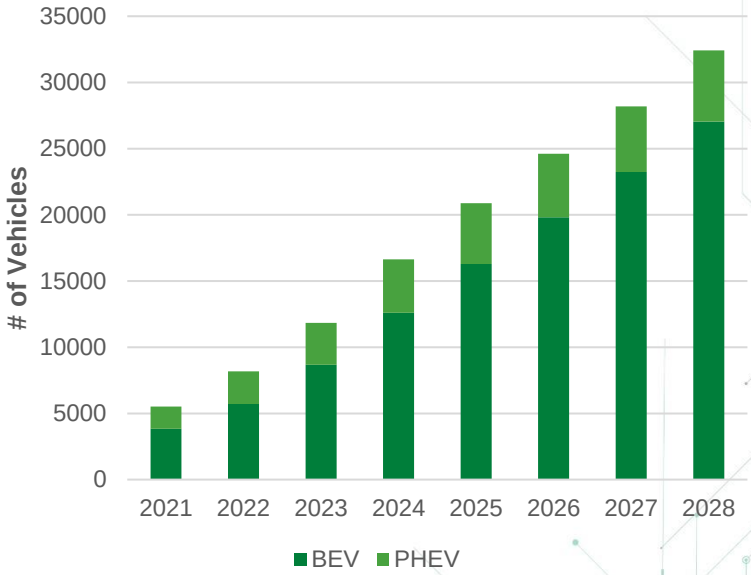
** As defined by SAE J1772*
‡ As defined by SAE J2954
*** As defined by IEC 61851-1*
**** Charge time dependent on vehicle's battery capacity and charge acceptance rate*

Global electric vehicle charging equipment market

Market trends and drivers

Increasing production of electrified vehicles: an estimated 5.5 million vehicles in 2021 growing to 33 million vehicles in 2028 ⇨ 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 efficiency, and a variety of support policies are the main drivers.
Majority of charging to occur at home or workplace during a span of several hours (AC charging) ⇨ bidirectional topologies are needed for smart grid
Limited charging grid capacity in most regions ⇨ emergence of combo ESS+PV with DC charger
Increasing voltage and power output of DC chargers for fast charging ⇨ 500 V to 800 V
Low-power DC charging solution in residential/campus settings will replace the AC charging solution to make charging faster (20 kW DC versus 7 kW AC)
DC chargers create a need for improved safety and additional components, such as advanced liquid-cooled cables, substations, and energy storage systems

Rapid growth of EV at ~25% CAGR



Source: IHS Report and Littelfuse estimates

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Acronyms:
PV: Photovoltaic
ESS: Energy Storage System
HEV: Battery-Powered Electric Vehicle
PHEV: Plug-In Hybrid Electric Vehicle

AC charging station

1 Power Board

- Fuse
- MOV
- AC Contactor
- AC Relay

2 Charging Gun

- Reed Sensor
- Temperature Sensor

3 Control Board

- Reed Relay
- TVS Diode
- Diode Array
- Linear Optocoupler
- Solid State Relay

4 Auxiliary Power Supply

- Fuse
- PPTC
- MOV
- SIDACtor®
- Schottky Diode

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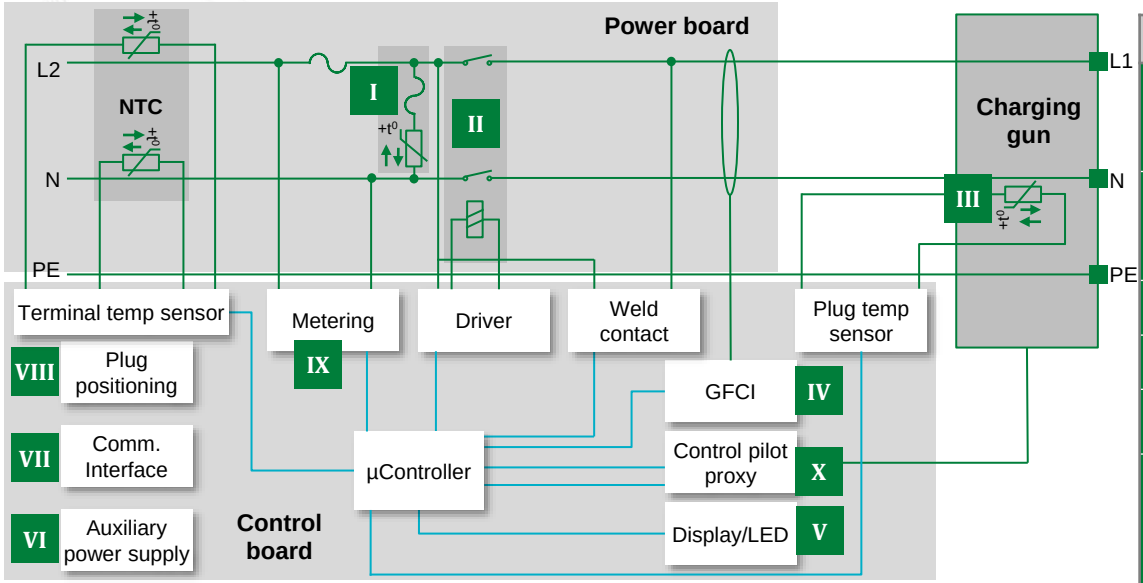
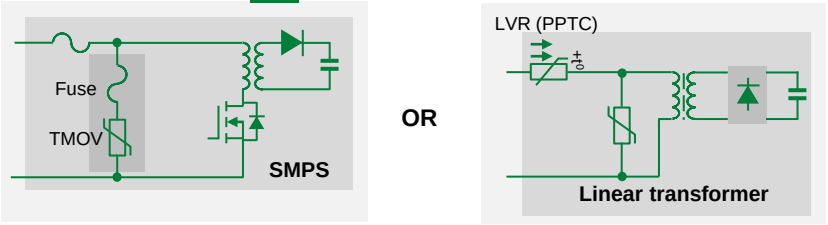
MOV: *Metal-oxide Varistor*
AC: *Alternate Current*

TVS: *Transient Voltage Suppression*
PPTC: *Polymer Positive Temperature Coefficient*

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

AC charging functional block diagram





	Technology	Series
I	Fuse	606, 505, 607
	MOV	TMOV, Xtreme
II	AC Contactor	HCC 1 & 2 Pole, HCC 3 & 4 Pole
	AC Relay	SC0x*
III	Temperature Sensor	PPG, USW, Glass Coated Thermistor
IV	Reed Relay	HE3600
V	TVS Diode Polymer ESD	SP1026 XGD10402
VI	Fuse + Varistor or PPTC + Varistor	215, 443E, TMOV or LVR + MOV
	Schottky Diode	DST, DSA, DSB
	SIDACtor + MOV	Pxxx0FNL + UltraMOV
VII	TVS Diode Array	AQ24CAN, SM712
VIII	Reed Sensor	59060, 59045
IX	Linear Optocoupler	LOC110ST
X	Solid State Relay	CPC1390GRTR, CPC1006NTR, CPC1017

Please contact Littelfuse Associates for details

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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
I	Fuse	Primary over-current protection of EV equipment	606, 505, 607	Enables robust yet compact design; can operate in extreme temperature environment	Rated voltage @ 500 VAC; 40−63 A rating available; small footprint
	MOV	Protects from power fluctuations or surges	TMOV, Xtreme	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
II	Contactors or Relays	Safety cutoff on the grid (power network) to prevent abnormal current supply	HCC 1 & 2 Pole, HCC 3 & 4 Pole	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
			SC0x*	PCB mount capable; higher flexibility for designers; compact design	Low heat generation and low coil power consumption; performance to meet regulatory UL/IEC compliance
III	Temperature Sensor	DC contacts hotspot detection	PPG, USW, Glass Coated Thermistor	Offers high accuracy; high reliability; excellent stability at high temperatures	Linear relationship between temp and resistance; temp range -50 °C to +500 °C
IV	Reed Relay	Low power switching with up to 2500 V isolation	HE3600	Low power consumption; galvanic isolation; immune to environmental effects	Miniature single in-line package; external magnetic shield option
V	TVS Diode Array Polymer ESD	Protects ICs from ESD through display	SP1026 XGD10402	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
VI	Fuse + Varistor	Protects SMPS from damages due to mech overloads, overheating, etc.	215, 443E, TMOV or LVR + MOV	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	Compliance with third-party safety standards such as UL/IEC
	PPTC + Varistor	Protects linear transformers from damages due to mech overloads, overheating, etc.	DST, DSA, DSB	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
	SIDACtor + MOV	Enhancing surge protection for auxiliary power supply	Pxxx0FNL + UltraMOV	Good clamping and fast response time for high-energy transient protection	3 kA, 8/20 µs surge capability to help protect AC lines from harmful transient surges
VII	TVS Diode Array	Protects CAN, Ethernet, RS-485 bus from ESD, EFT, and voltage transient	AQ24CAN, SM712	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
VIII	Reed Sensor	Access panel for position sensing	59060, 59045	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
IX	Linear Optocoupler	Isolated main voltage sensing in the system	LOC110ST	High gain stability; low input/output capacitance; low power consumption	LED operating range: 2−10 mA; isolation: 3750 V_{RMS}
X	Solid State Relay	Controls board isolation	CPC1390GRTR, CPC1006NTR, CPC1017	High reliability; low drive current; no EMI/RFI generation	Isolation voltage up to 5000 V_{RMS}; low off-state leakage; SMD package

DC charging station

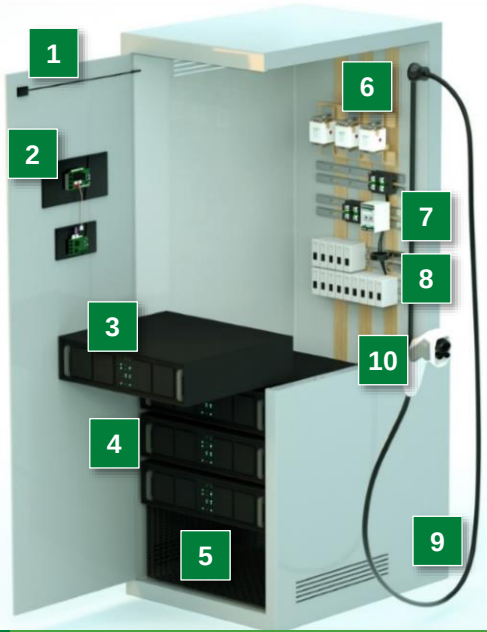
1 Service Access Panel
- Reed Sensor

2 User Interface
- TVS Diode Array
- Polymer ESD Suppressor

3 Communication
- TVS Diode Array

4 Rectification & PFC
- SiC/Si MOSFET
- Rectifier Diode/Module
- Gate Driver
- Temperature Sensor

5 DC-DC Conversion
- SiC/Si MOSFET
- Rectifier Diode/Module
- Gate Driver
- Temperature Sensor



10 Charging Plug
- Temperature Sensor
- Reed Sensor

6 Power Distribution Unit
- Fuse

7 Input Protection
- Fuse
- Surge Protection Device
- TVS Diode
- Current Transformer
- AC Earth Fault Relay

8 DC Output Protection
- DC Fuse
- HVDC Contactor
- Earth Fault Relay

9 Auxiliary Power Supply
- Fuse
- MOV, GDT, SIDACtor® + MOV
- Si MOSFET
- Rectifier Diode

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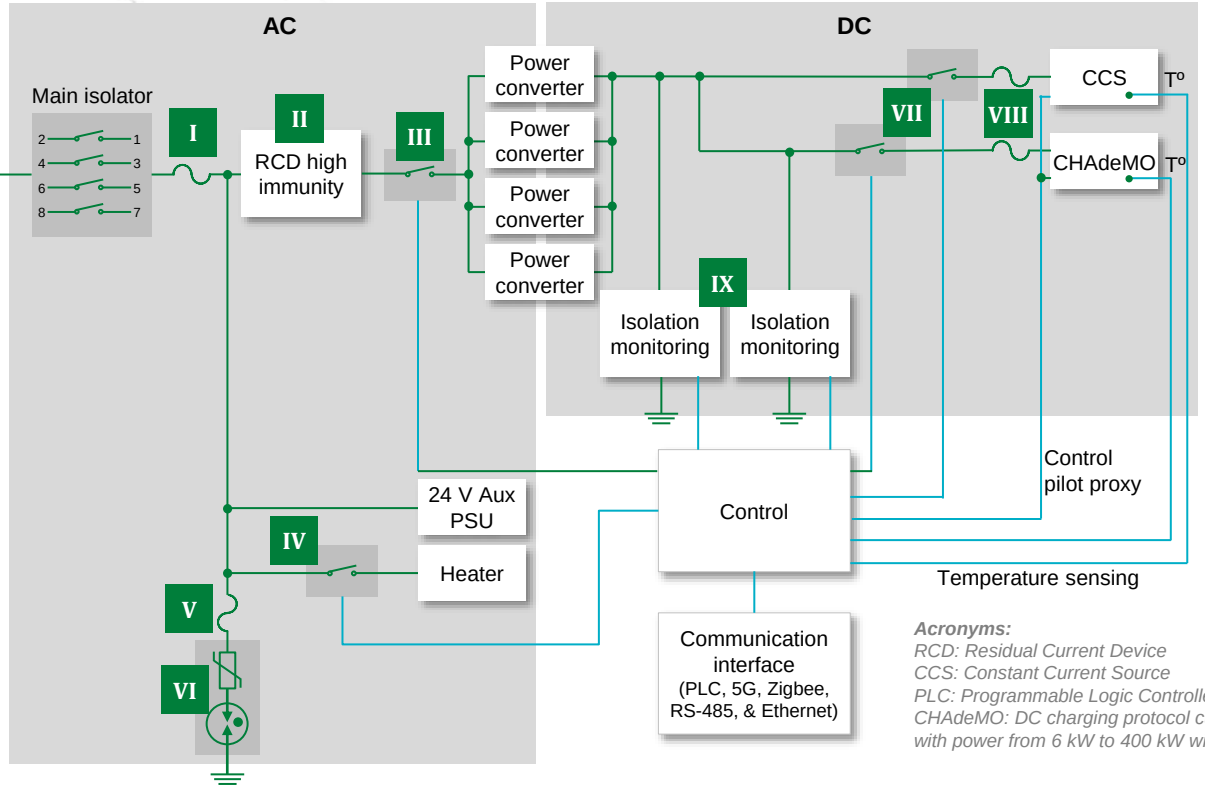
TVS: *Transient Voltage Suppression*
SiC: *Silicon Carbide*
Si: *Silicon*
AC: *Alternate Current*
DC: *Direct Current*
HVDC: *Heavy Voltage Direct Current*
MOV: *Metal-oxide Varistor*
GDT: *Gas Discharge Tubes*

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

DC charger cabinet-level protection



	Technology	Series
I	Fuse x 3	PSR, L50QS, L75QS
II	Ground Fault Relay	SE-704, SE-CS30
III	AC Contactor	HCD
IV	AC Relay	SC0x*
V	Fuse + Fuseholder	LVSP + LPSM
VI	Surge Protection Device	SPD Type 2
VII	DC Contactor Relay x 2	DCNxx
VIII	Fuse x 3	SFPJ, PSR, EV1K
IX	Solid State Relay	CPC1981Y, PLA192E, PLA193E

** Please contact Littelfuse Associates for details*

Acronyms:
RCD: Residual Current Device
CCS: Constant Current Source
PLC: Programmable Logic Controller
CHAdeMO: DC charging protocol currently enabling EV charging with power from 6 kW to 400 kW with 900 kW in preparation

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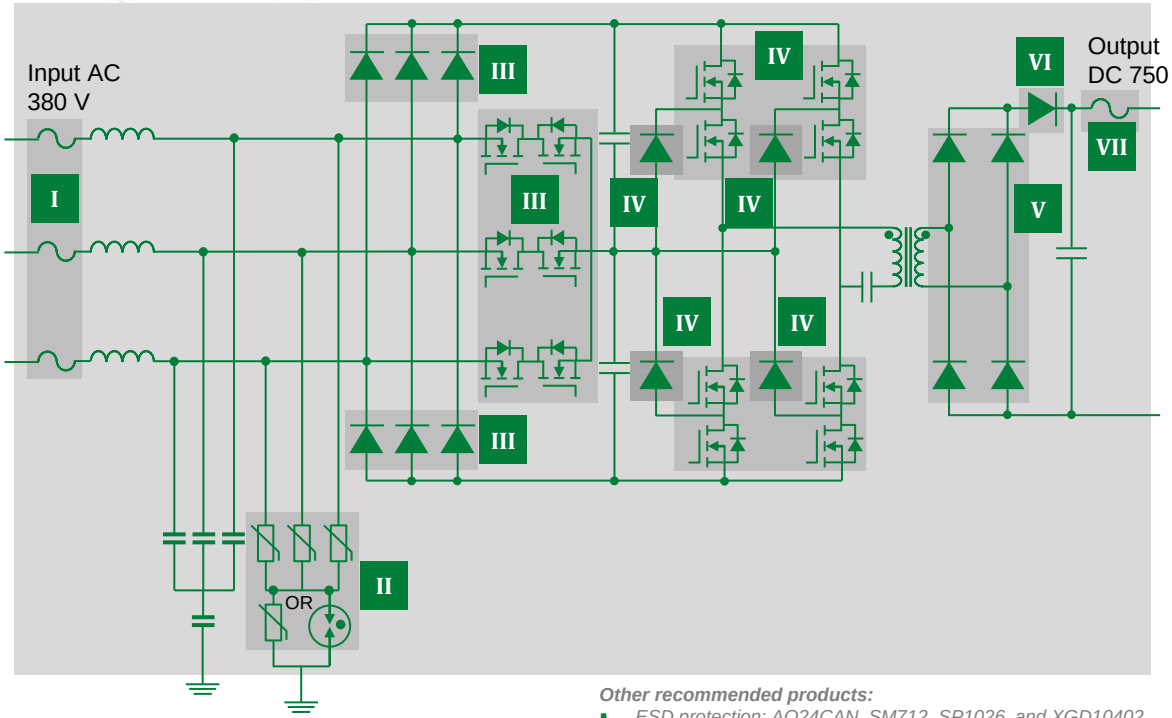
Click on the product series in the table below for more info

Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
I	Fuse x 3	Protects semiconductor devices	PSR	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
II	Current Transformer	Offers ground-fault detection and protection	SE-CS30	Specifically designed for low-level detection; flux conditioner is included to prevent saturation	Turns ratio 600:1 and current rating 30:0.05 A
	AC Earth-Fault Relay		SE-704	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)
III	AC Contactor	Safety cutoff on the grid (power network) to prevent abnormal current supply	HCD	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
IV	AC Relay		SC0x*	PCB mount capable; higher flexibility for designers; compact design	Low heat generation and low coil power consumption; performance to meet regulatory UL/IEC compliance
V	Fuse + Fuseholder	This is an optional surge suppression fuse (+ fuse holder) intended to protect surge protection devices	LVSP + LPSM	Very current limiting under AC short-circuit conditions; available in multiple mounting configurations (cartridge, bolt-in, PC board mount)	Survive the 8x20 µs lightning surges described in various standards (UL 1449, IEC 61000-4-5, and IEEE C62.41) without opening
VI	Surge Protection Device	Protects from power fluctuations or surges	SPD Type 2	Withstands high-energy transients to prevent disruption, downtime, and degradation	20 kA nominal interrupting rating and 50 kA maximum interrupting rating
VII	DC Contactor Relay x 2	The main contactors connect and disconnect the DC charging unit	DCNxx	Allows a low-voltage signal to switch the contacts for a high-voltage signal	Wide range of capabilities–can switch from tens of amps to thousands of amps and tens of volts to thousands of volts
VIII	Fuse x 3	Protects semiconductor devices	SFPJ, PSR, EV1K	Lower I^2t performance allows for quick response to protect devices from higher heat energy	500–1000 V_{DC}, 40–2000 A
IX	Solid State Relay	DC leakage current detection	CPC1981Y, PLA192E, PLA193E	High reliability; low drive power requirements; no EMI/RFI generation	2500–5000 V_{RMS} input/output isolation; handle load currents up to 0.25 A; power SIP & SMD package

DC charger subunit power converter
(15~20 kW−Vienna Rectifier + Three-level Inverter)

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



	Technology	Series
I	Fuse	606, 505, 607
II	MOV (Secondary protection)	TMOV, UltraMOV
	GDT (Secondary protection)	CG2, CG3
	SIDACtor® + MOV (Secondary protection)	Pxxx0FNL + UltraMOV
III	Diode	DSEPxx, DMA, DST, DSA, DSB
	MOSFET	X-Class, X2-Class, X3-Class
	Gate Driver	IXD_6xx
IV	MOSFET	X-Class, X2-Class, HiPerFET™
	Diode	LSIC2SD, DHG, DSEI, DSEPxx
	Gate Driver	IXD_6xx, IX4351NE
V	Diode	DSEPxx
VI	Diode	DLAxx, DSIxx, DMA, DHG, DSEI
VII	Fuse	SPF, 526*, 607, 828

** Please contact Littelfuse Associates for details*

Other recommended products:

- *ESD protection: AQ24CAN, SM712, SP1026, and XGD10402*
- *Temperature sensing: USUR1000 and KC*

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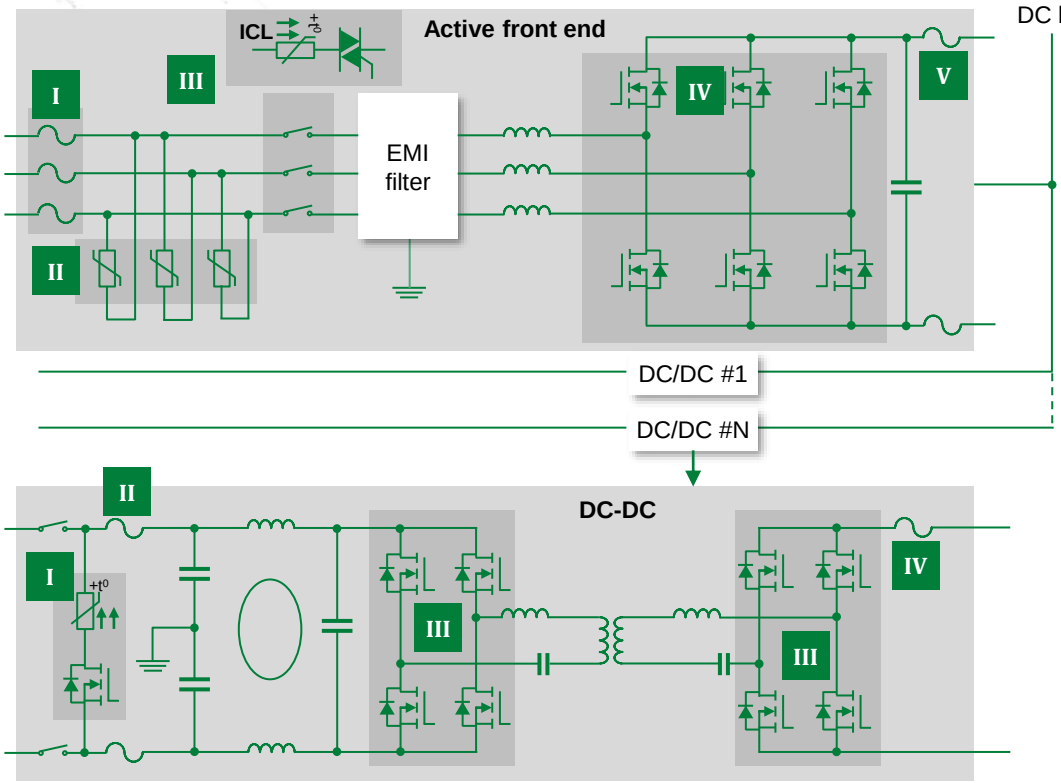
Click on the product series in the table below for more info

Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
I	Fuse	Overcurrent protection of auxiliary power supply	606, 505, 607	Enables robust yet compact design; can operate in extreme temperature environment	Rated voltage @ 500 VAC; 40−63 A rating available; small footprint
II	MOV	GDT in series with TMOV protects the auxiliary power supply unit from voltage transients induced by lightning	TMOV, UltraMOV	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		CG2, CG3	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	Pxxx0FNL + UltraMOV	Good clamping and fast response time for high-energy transient protection	3 kA, 8/20 µs surge capability to help protect AC lines from harmful transient surges.
III	Diode	Vienna rectifier	DSEPxx, DMA, DST, DSA, DSB	Improves power supply unit efficiency	Low forward voltage drop; high-frequency operation; high junction temperature
	MOSFET		X-Class, X2-Class, X3-Class	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Gate Driver	Controls the switching MOSFETs	IXD_6xx	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
IV	SiC or Si MOSFET	Primary side of the DC-DC converter	X-Class, X2-Class, HiPerFET™	Optimized for high-frequency applications	Ultra-low on-resistance $R_{DS(ON)}$ and gate charge Qg; dv/dt ruggedness
	Diode		LSIC2SD, DHG, DSEI, DSEPxx	Reduces switching losses; increases efficiency	High surge capability; negligible I_{RR}; Tj 175 °C
	Gate Driver	Controls the switching MOSFETs	IXD_6xx, IX4351NE	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
V	Diode	Secondary side output rectification of DC-DC converter	DSEPxx	Reduces switching losses; increases efficiency	High surge capability; negligible I_{RR}; Tj 175 °C
VI	Diode	Redundant diode for secondary protection	DLAxx, DSIxx, DMA, DHG, DSEI	Compact design; low turn-on loss; lower power dissipation	High voltage options; very low forward voltage drop; small form factor
VII	Fuse	Protects semiconductor devices	SPF, 526*, 607, 828	Lower I^2t performance allows for quick response to protect devices from higher heat energy	500–1000 V_{DC}, 1 A–63 A; compact size (10x32 mm or 10x38 mm); interrupt rating: 10–50 kA

DC charger subunit power converter (Bidirectional SiC-based power converter)

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



Active front end

	Technology	Series
I	Fuse	606, 505, 607
II	MOV	MOV, Xtreme
III	Discrete Thyristor	SCR
IV	SiC MOSFET or Phase Leg IGBT	LSIC
		SMPD
V	Fuse	SPF, 526*, 607, 828

DC–DC converter

	Technology	Series
I	Discrete MOSFET	IXTA 1200V TO263
II	Fuse	SPF
III	SiC MOSFET or Phase Leg IGBT	LSIC
		SMPD
IV	Fuse	SPF, 526*, 607, 828

** Please contact Littelfuse Associates for details*

Acronyms:
ICL: Inrush Current Limiters

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

Features and benefits of Littelfuse solutions

Active front end

	Technology	Function in application	Product series	Benefits	Features
I	Fuse	Overcurrent protection of auxiliary power supply	606, 505, 607	Enables robust yet compact design; can operate in extreme temperature environment	Rated voltage @ 500 VAC; 40−63 A rating available; small footprint
II	MOV	Protects from power fluctuations or surges	MOV, Xtreme	Reduces customer qualification time by complying with third-party safety standards such as UL/IEC	High energy absorption capability; UL/IEC approved voltage rating: 130–680 VAC
III	Discrete Thyristor	Inrush current limiter	SCR	Protects the body diode of the rectification circuitry	Broadest portfolio of low- and medium-voltage SCR devices; multiple package options
IV	SiC MOSFET or Phase Leg IGBT	Active rectification	LSIC	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
			SMPD	Board space savings; offers more design flexibility	Ultra-low and compact package profile; low package inductance; excellent thermal capability; high power cycling capability
V	Fuse	Protects semiconductor devices	SPF, 526*, 607, 828	Lower I^2t performance allows a quick response to protect devices from higher heat energy	500–1000 V_{DC}, 1 A–63 A; compact size (10x32 mm or 10x38 mm); interrupt rating: 10–50 kA

DC−DC converter

	Technology	Function in application	Product series	Benefits	Features
I	Discrete MOSFET	Discharges circuit (prevents electrical hazards during maintenance)	IXTA 1200V TO263	Easy to mount; space savings; high power density	HV package; fast intrinsic diode; avalanche rated; high blocking voltage
II	Fuse	Protects output semiconductor devices	SPF	Lower I^2t performance allows a quick response to protect devices from higher heat energy	1000 V_{DC}, 1–30 A ratings available; UL and IEC approved
III	SiC MOSFET or Phase Leg IGBT	Active rectification	LSIC	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
			SMPD	Board space savings; offers more design flexibility	Ultra-low and compact package profile; low package inductance; excellent thermal capability; high power cycling capability
IV	Fuse	Protects input semiconductor devices	SPF, 526*, 607, 828	Lower I^2t performance allows a quick response to protect devices from higher heat energy	500–1000 V_{DC}, 1 A–63 A; compact size (10x32 mm or 10x38 mm); interrupt rating: 10–50 kA

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 the 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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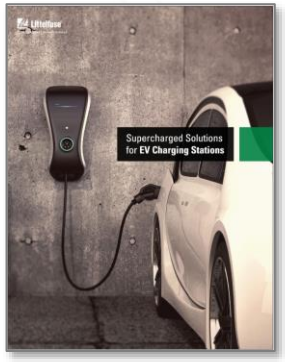
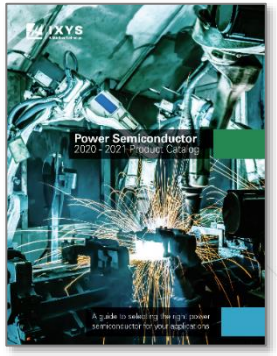
EV Charging Brochure



Circuit Protection Catalog

Sensor Selection Guide

Power Semiconductor Catalog

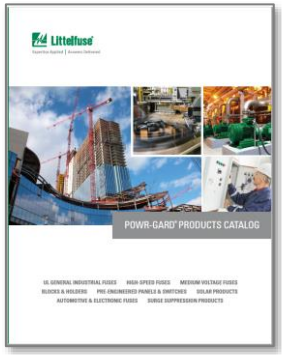


Click on images to open the catalogs

Integrated Circuits Catalog

Surge Protection Devices Catalog

Industrial Fuses Catalog



Power Relay & Control Catalog

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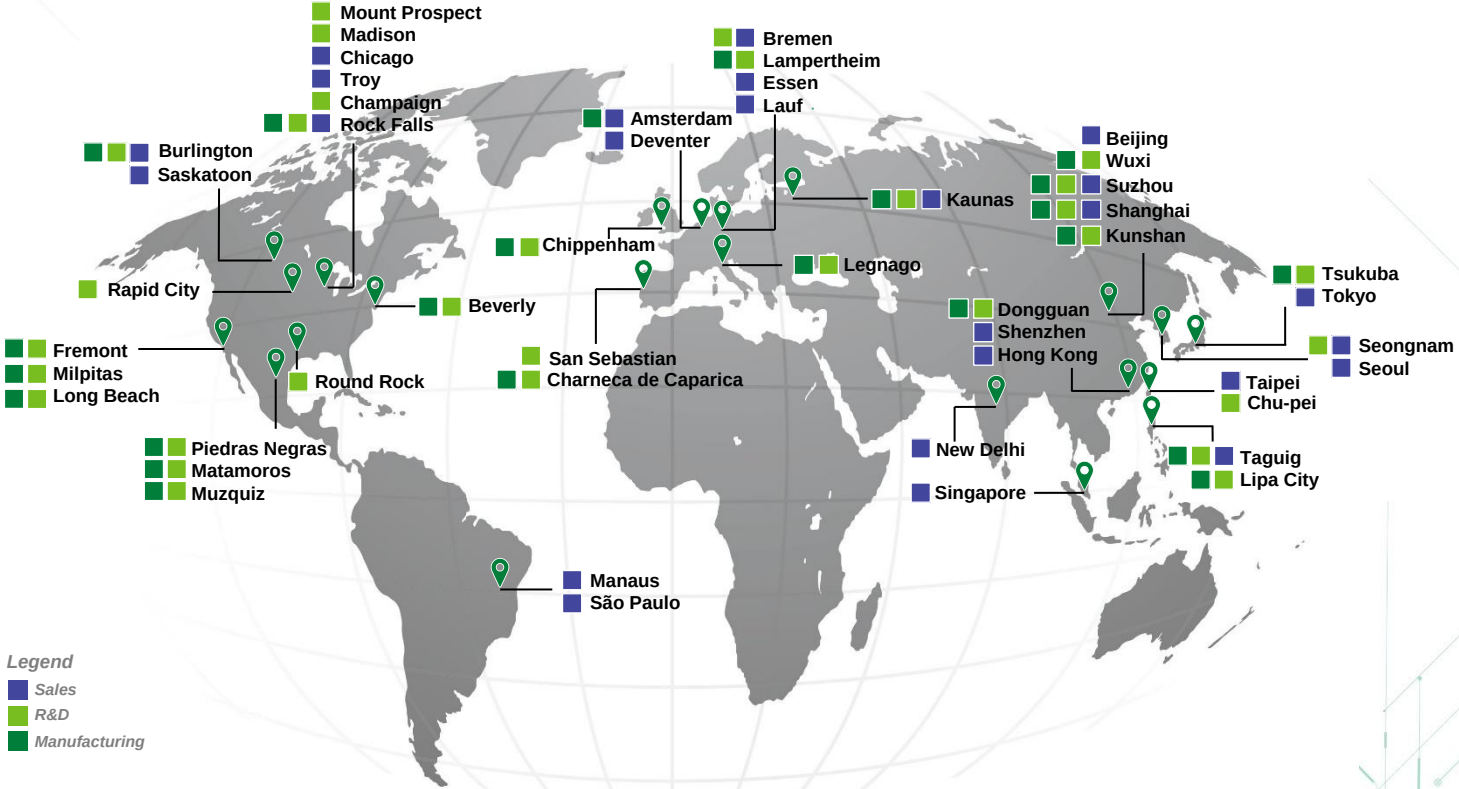
Local resources supporting our global customers



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Partner for tomorrow’s electronic systems

BROAD PRODUCT PORTFOLIO

An industrial technology manufacturing company empowering a sustainable, connected, and safer world

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 AND REGULATORY EXPERTISE

To 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 for global regulatory standards

GLOBAL MANUFACTURING

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

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IXYS
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