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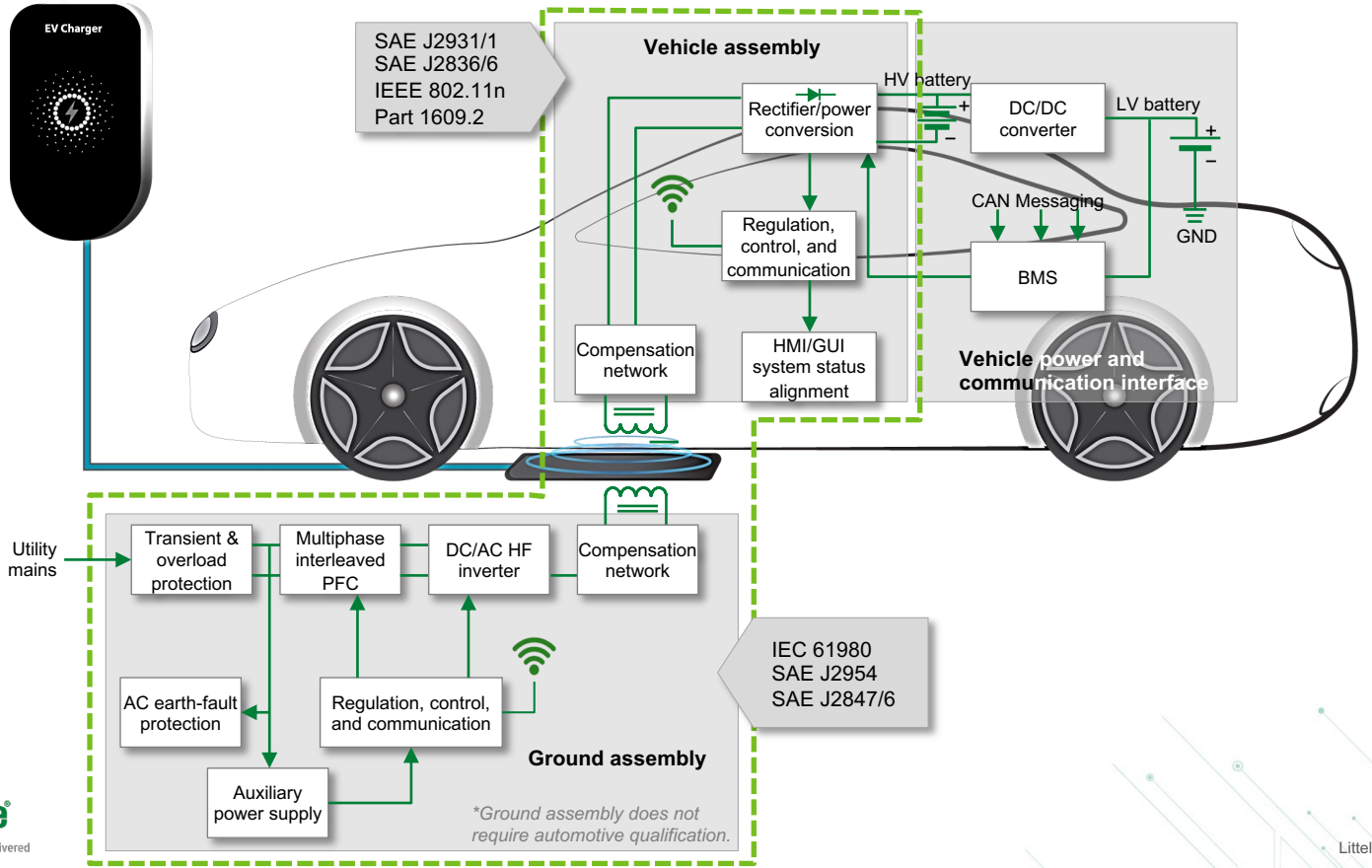
Electric Vehicle Wireless Charging Solutions

EV Infrastructure

REV0824

Wireless charging overview



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Global wireless EV charging market growing at a CAGR of ~77%

Market trends and drivers

A seamless charging experience saves time and effort for fleet managers and electric vehicle (EV) owners, making it an ideal solution for private fleet or public charging stations.

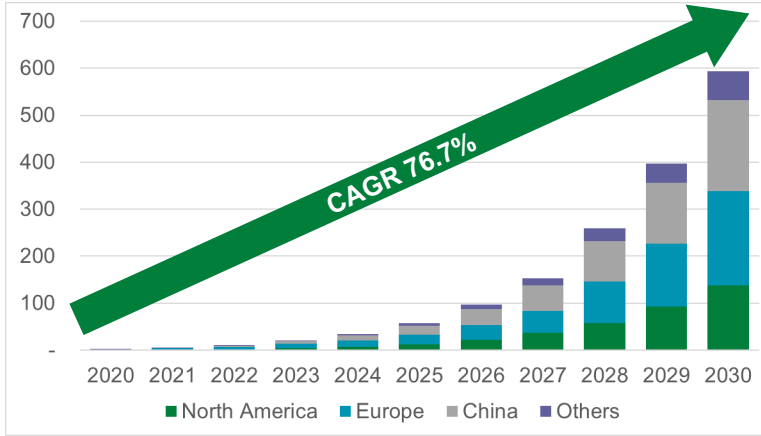
The charging process is safer since there are no exposed connectors or cables, minimizing the risk of physical damage and electrical hazards. This ensures much more durable and long-lasting infrastructure.

With the advancement of self-driving technology, autonomous EVs are becoming a reality. Wireless EV chargers make the charging experience more convenient and user-friendly.

The total addressable market (TAM) for industrial chargers (automated guided vehicles (AGVs), autonomous mobile robots (AMRs), and industrial trucks) is valued at $12.5 billion.

Dynamic-charging wireless electric roads

Wireless charge point sales by region: 2020–2030



Wireless Charging System Global Major Players

Americas
- WiTricity
- Helix Wireless Evatran Group, Inc.
- Momentum Dynamics Corp.
- HEVO, Inc.
- Induct EV
- Mojo Mobility
- Wave, Inc.
- Plugless Power

Europe/Israel
- Continental AG
- Electreon, Inc.
- Wiferion
- HELLA KGaA Hueck & Co.
- Preh GmbH
- MALHE

Asia
- Daihen Corp.
- ZTE Corp.
- Toshiba Corp.
- Toyota Motor Corp.

Sources: Guidehouse Report 2021

Wireless charging system

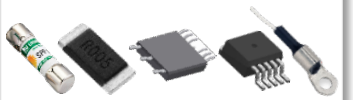
1 Power Distribution Unit
AC Fuse, Surge Protection Device

2 Input Protection
HC Fuse, MOV, GDT, TVS Diode

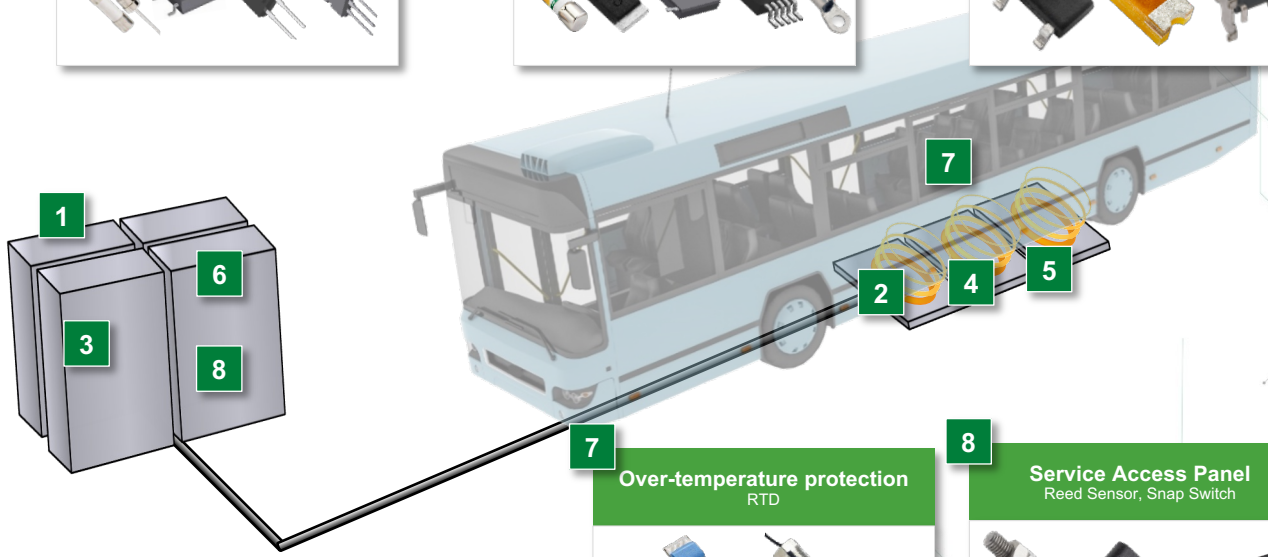
3 Earth-fault protection
Residual Current Monitor,
Ground Fault Relay

4 Auxiliary Power Supply
Fuse, Rectifier Diode,
SiC MOSFET, Diode

5 Power conversion
Fuse, SiC/Si MOSFET, Current Sensor,
Gate Driver, Temperature Sensor

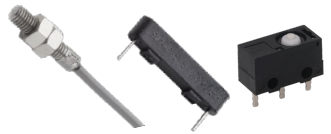


6 User interface & communication
TVS Diode Array, Polymer ESD
Tactile Switch



7 Over-temperature protection
RTD

8 Service Access Panel
Reed Sensor, Snap Switch



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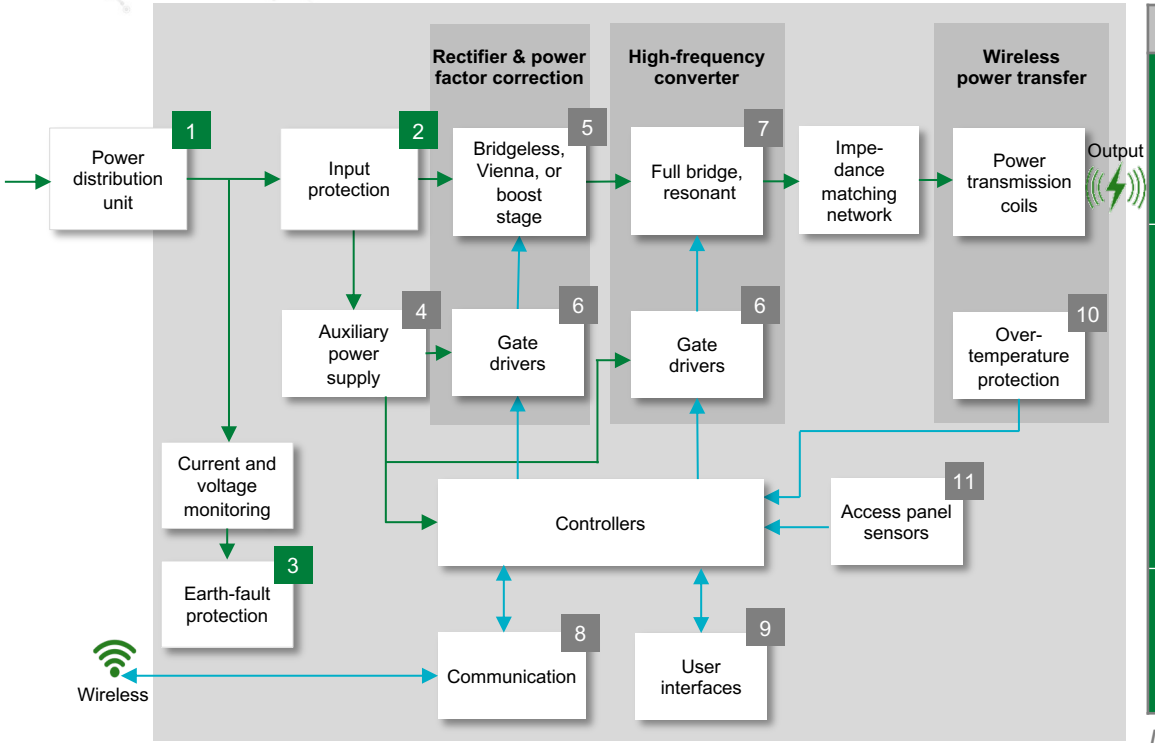
Click the product series in the table below for more info

Wireless charger functional block diagram



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

Legend:
Power
Data

	Technology	Product series
1	AC Fuse (Cabinet Level)	JLLS, JLLN, KLKD
	Surge Protection	SPD Type 2
2	HC Fuse (Primary protection)	606
	Fast-Acting Fuse (Secondary protection)	314, 324
	MOV	TMOV, UltraMOV
	GDT	CG2, CG3
	TVS Diode	High Voltage AK, LTKAK
3	Residual Current Monitor	RCM20-01, RCMP20-01, RCMP20-03
	Ground Fault Relay	SE-704, SE-CS30

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

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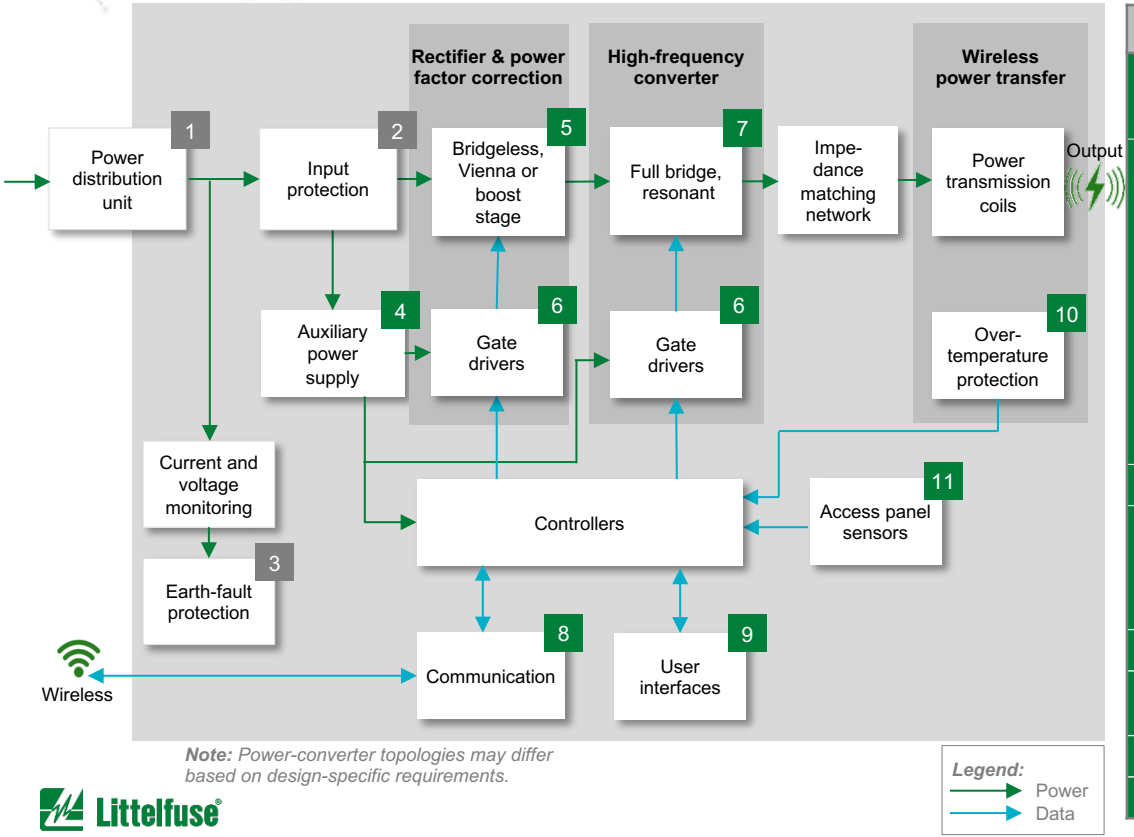
Click the product series in the table below for more info

Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
1	AC Fuse (Cabinet Level)	Provides fast-acting overload and short-circuit protection	JLLS, JLLN, KLKD	Reduces damage to equipment caused by heating and magnetic effects of short circuit currents	Extremely current limiting; small footprint 200 kA interrupting rating
	Surge protection	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
2	HC Fuse (Primary protection)	Primary overcurrent protection of EV equipment	606	Enables robust yet compact design; can operate in extreme temperature environments	Rated voltage @ 500 VAC; 40 A to 63 A rating available; small footprint
	Fast-Acting Fuse (Secondary protection)	Overcurrent protection of auxiliary power supply	314, 324	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	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
	TVS Diode	Protects power line from transient surge	High Voltage AK, LTKAK	Good clamping and fast response time for high-energy transient protection	High power TVS 8/20 µs rating from 1 kA to 20 kA in axial-lead or SMT form factor
3	Residual Current Monitor	Detects DC and AC residual currents to the earth in 50 Hz / 60 Hz AC installations	RCM20-01, RCMP20-01, RCMP20-03	Compact solution designed to be panel mounted or PCB mounted	Operates from a 12−24 VDC supply; helps with IEC61980 compliance
	Current Transformer	Offers ground-fault detection and protection	SE-704	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-CS30	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 series
4	Schottky Diode	DST, DSA, DSB
	Si MOSFET	Polar™
5	Rectifier Diode	DMA
	Rectifier Module	MDD, VUO, MDNA
	SiC/Si MOSFET *OR* Discrete IGBT	LSIC1MO/ X2-Class, SMPD *OR* XPT
	Diode	LSIC2SD, DHG, DSEI
	High-Speed Fuse	PSR, L50QS, L75QS
	Temperature Sensor	USUR1000
6	Gate Driver	IXDN609, IX4352NE
7	SiC MOSFET	LSIC1MO, MCL10P1200LB
	Diode	LSIC2SD, DHG, DSEI
	Temperature Sensor	USUR1000, KC
8	TVS Diode Array	AQ24CAN, SM24CANx
9	TVS Diode Array, Polymer ESD	SP1026, XGD10402
10	RTD	PPG, USW, Glass Coated
11	Reed Switch	59060, 59045

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Click the product series in the table below for more info

Features and benefits of Littelfuse solutions

	Technology	Function in application	Product series	Benefits	Features
4	Schottky Diode	Provides output rectification in auxiliary power supply	DST, DSA, DSB	Improves power supply unit efficiency	Low forward voltage drop; high-frequency operation; high junction temperature
	Si MOSFET	High-speed switching	Polar™	Easy to mount; space saving; high power density	Low $R_{DS(on)}$ and Q_g; avalanche rated; international standard packages; low package inductance
5	Rectifier Diode	Converts AC line voltage supplied to the drive to DC	DMA	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	Converts AC line voltage supplied to the drive to DC	MDD, VUO, MDNA	Compact design; better electrical isolations	Package with DCB ceramic; very low forward voltage drop and low leakage current
	SiC/Si MOSFET ***OR*** Discrete IGBT	Boosts converter for high-frequency switching in the PFC circuit	LSIC1MO/ X2-Class, SMPD ***OR*** XPT	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Diode		LSIC2SD, DHG, DSEI	Reduces switching losses; increases efficiency	High surge capability; negligible I_{RR}; Tj 175 °C
	High-Speed Fuse	Protects semiconductor devices	PSR, L50QS, L75QS	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
	Temperature Sensor	Semiconductor temperature measurement	USUR1000	Rapid thermal response and long-time reliability	UL recognized; wide temperature range: -40 °C to 125 °C
6	Gate Driver	Controls the switching MOSFETs/IGBTs	IXDN609, IX4352NE	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	SiC MOSFET	High-frequency switching and rectification	LSIC1MO, MCL10P1200LB	Optimized for high-frequency applications	Ultra-low output capacitance and on-resistance
	Diode		LSIC2SD, DHG, DSEI	Reduces switching losses; increases efficiency	High surge capability; negligible I_{RR}; Tj 175 °C
	Temperature Sensor	Semiconductor temperature measurement	USUR1000, KC	Rapid thermal response and long-time reliability	UL recognized; wide temperature range: -40 °C to 125 °C
8	TVS Diode Array	Protects CAN bus from ESD, EFT, and voltage transient	AQ24CAN, SM24CANx	Ensures reliability of the equipment without performance degradation	Meets ESD protection levels specified under IEC 61000-4-2 and ISO10605; low leakage current and clamping voltage
9	TVS Diode Array Polymer ESD	Protects ICs from ESD through display	SP1026, XGD10402	Smaller form factor and multiline protection enables ease of design	Low capacitance of 1.0 pF per I/O
10	RTD	Temperature sensing	PPG, USW, Glass Coated	Offers high accuracy, high reliability, and excellent stability at high temperatures	Linear relationship between temp and resistance; temperature range -50 °C to +500 °C
11	Reed Switch	Charging plus position sensing	59060, 59045	Robust design; well suited for usage in high-moisture and contaminated environment	Hermetically sealed; magnetically operated contacts; certified for use in NA and Europe

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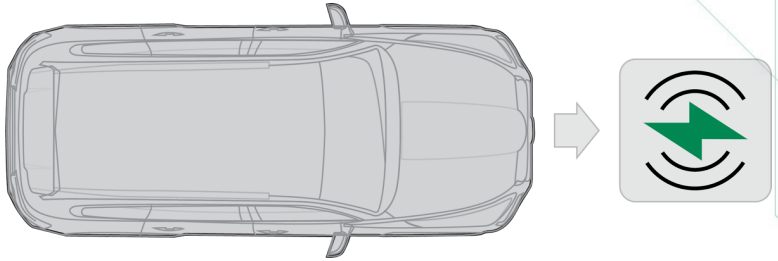
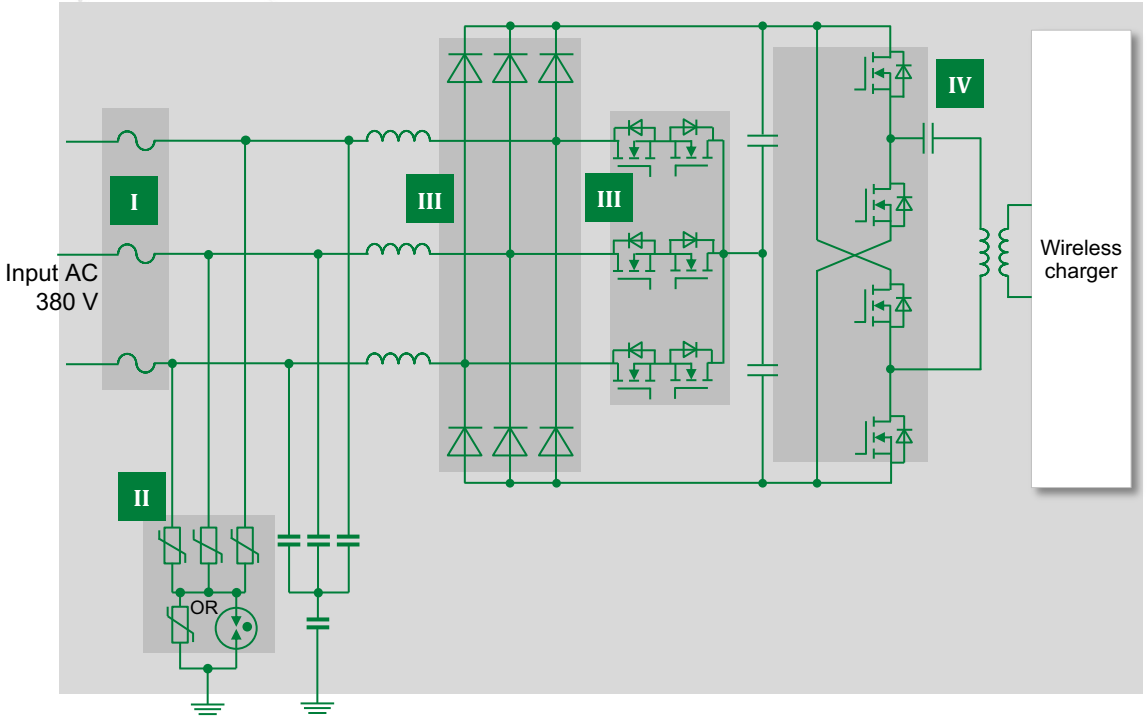


Wireless charging schematic
for power conversion

Click the product series in the table below for more info

Wireless charger power converter



	Technology	Product series
I	Fuse	606, 505, 607
II	MOV (Secondary protection)	TMOV, UltraMOV, SM10
	GDT (Secondary protection)	CG2, CG3
	SIDACtor® + MOV (Secondary protection)	Pxxx0FNL + UltraMOV
III	Diode	DSEPxx, DSEI
	MOSFET	X2-Class, X3-Class
	Gate Driver	IXD_6xx, IX4352NE
IV	Discrete Si/SiC MOSFET/SMPD	HiPerFET™, MCL10P1200LB
	Gate Driver	IXD_6xx, IX4352NE

Other recommended products:

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

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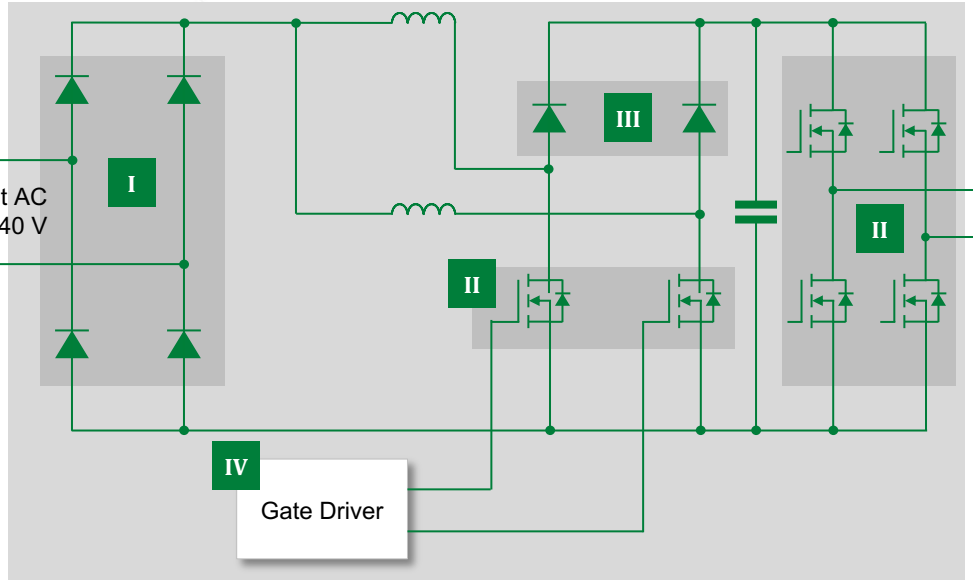
Click the product series in the table below for more info

Wireless charging system: Interleaved PFC circuit



	Technology	Product series
I	Bridge Rectifier	DMA200X1600NA, MDNA240U2200ED
II	Si MOSFET	X2-Class, X3-Class, SMPD
	SiC MOSFET	LSIC1MO
	IGBT	XPT™, MIXA, MIXG
	TVS Diode	TPSMx
	Temperature Sensor	setP™, USUR1000, Epoxy Coated Thermistor
III	Diode	LSIC2SD, SONIC-FRD™, FRED DSE*
IV	Gate Driver	IXDN604, IX4340N, IX332B, IXDN609, IX2113, IX332B

** Please contact Littelfuse Sales for more details.*

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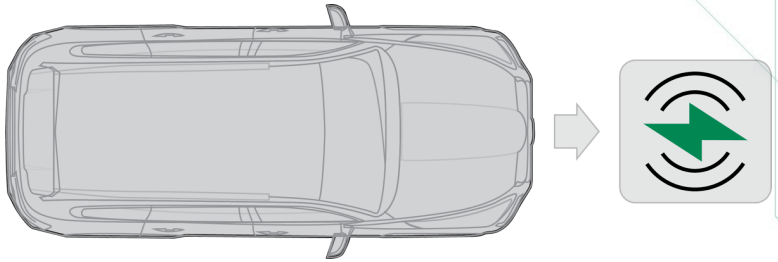


Safety standards for EV wireless charging

Select standards for EV charging equipment

Standard	Title	General Scope	Region
IEC 61851	Electric Vehicle Conductive Charging System	Various parts of this standard cover general requirements, along with AC chargers and DC chargers specifically.	Global
IEC 62196	Plugs, Socket Outlets, Vehicle Connectors, and Vehicle Inlets−Conductive Charging of Electric Vehicles	Standards for charging plugs, sockets, and connectors.	Global
IEC 61980	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	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	Connection Set for Conductive Charging of Electric Vehicles	Standards for charging plugs in China.	China
JIS TS D 0007	Basic Function of Quick Charger for the Electric Vehicle	Standard for CHAdeMO (DC) chargers in Japan.	Japan
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, and safety and testing for wireless chargers in North America.	North America
UL 2594	Standard for Electric Vehicle Supply Equipment	Safety standard for AC chargers in North America. Tri-national standard for the United States, 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 DC chargers in the United States.	U.S.

** J1772™ and J2954™ are registered trademarks of SAE International.*

IEC 61980-3 and SAE J2594 follow the same power classifications

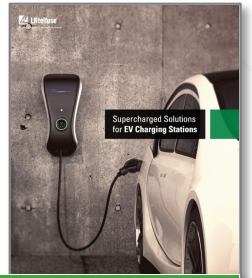
	WPT* Power Class			
	WPT1	**WPT2**	**WPT3**	**WPT4**
Maximum input	3.7 kVA	7.7 kVA	11.1 kVA	22 kVA
Minimum target efficiency at nominal x,y alignment	> 85%	> 85%	> 85%	TBD next phase
Minimum target efficiency at offset position	> 80%	> 80%	> 80%	TBD next phase

Source: *SAE J2594*
IEC 61980-3 follows the same power classification.
**WPT = Wireless Power Transfer*

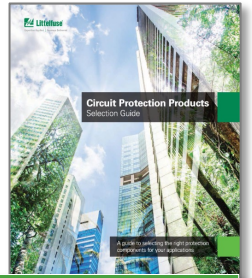
To address the emergence of high-power pilot projects far above 22 kW, new standards for high-power wireless charger are under development.

Additional information can be found at Littelfuse.com

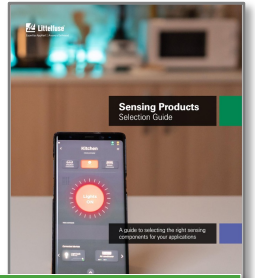
Explore the world of Littelfuse products and applications with ecatalogs (ecatalogs.littelfuse.com)



EV Charging Brochure



Circuit Protection Selection Guide

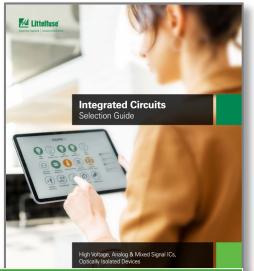


Sensor Selection Guide

Power Semiconductor Catalog

C&K Automotive Switch Flyer

Click on the images for more information

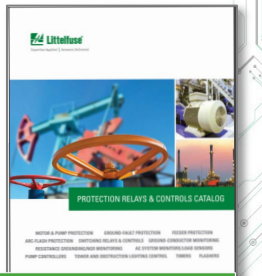


Integrated Circuits Selection Guide

Surge Protection Devices Catalog

Scan the code to learn more!

Industrial Fuses Catalog



Power Relay & Control Catalog

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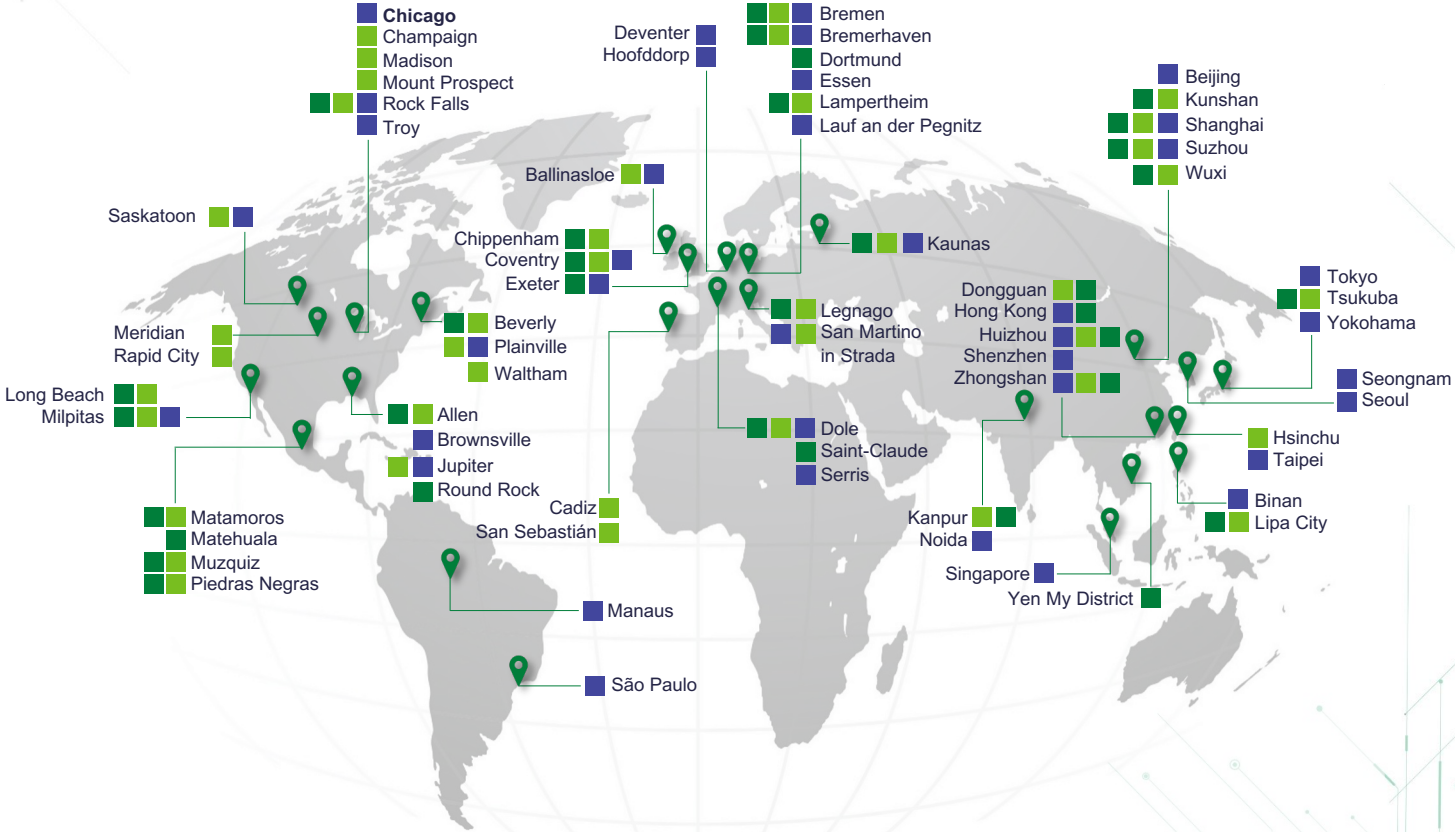
Local resources supporting our global customers



Legend

- ***Sales***
- ***R&D***
- ***Manufacturing***

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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

Testing Capabilities

We help customers get products to market faster, we offer certification testing to global regulatory standards

Application Expertise

Our engineers partner directly with customers to help speed up product design and meet their unique needs

Compliance & Regulatory

We help customers in the design process to account for requirements set by global regulatory authorities

Global Customer Service

Our global customer service team is with you to anticipate your needs and ensure a seamless experience

Global Manufacturing

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

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