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EV Charging Infrastructure

EV infrastructure

REV0219

Types of electric vehicle charging stations

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

AC Level 1

- 120 VAC, 1-phase, 12 A, or 16 A max continuous current

Mode 1 (AC)

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

Mode 2 (AC)

- 250 VAC, 1-phase, 32 A max. -OR- 480 VAC, 3-phase, 32 A max.
- Cord with control pilot and shock protection

- It delivers AC power from the wall socket to the vehicle's on-board charger
- It typically takes 8–12 hours* to charge fully depleted battery

AC Level 2

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

Mode 3 (AC)

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

- It delivers AC power from the electrical supply to the vehicle's on-board charger
- It typically takes 4–6 hours* to charge fully depleted battery

DC Fast Charger

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

Mode 4 (DC)

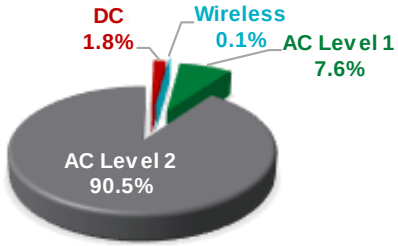
- AC or DC input supply, cord or permanently connected, with control pilot & shock protection

- It delivers DC power, bypassing the vehicle's on-board charger
- It typically provides 80% charge of a fully depleted battery within 30 minutes*

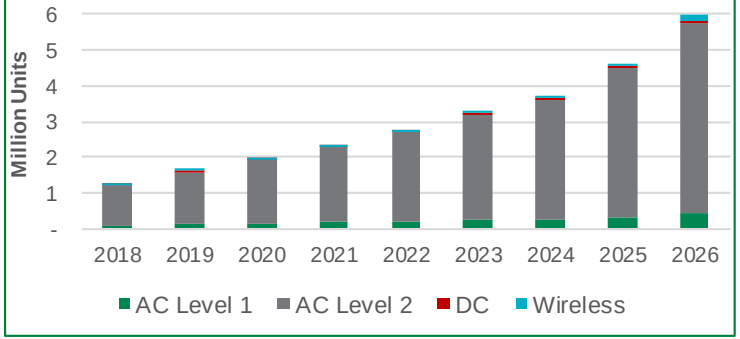
** The charge time is dependent on the vehicle's battery capacity and charge acceptance rate*

Global electric vehicle charging equipment market

EV Charging Equipment, by Type, in 2018



EV Charging Equipment Forecast



Source: Navigant Research – Market Data: Electric Vehicle Charging Equipment, 2017

Market Trends and Drivers

The production of electrified vehicles is increasing: estimated 6 million vehicles in 2019, growing to 16 million vehicles in 2023
There is limited charging infrastructure in most regions
The production of new EV charging equipment will increase at a compound annual growth rate (CAGR) of 22% between 2018 and 2026
The majority of charging occurs at the home or workplace during a span of several hours (AC charging)
There is consumer demand for charging times that emulate fuel refilling time for long-distance trips (DC charging)
The voltage and power output of DC chargers is increasing to support fast charging
Business models are evolving: increase property value; revenue generation

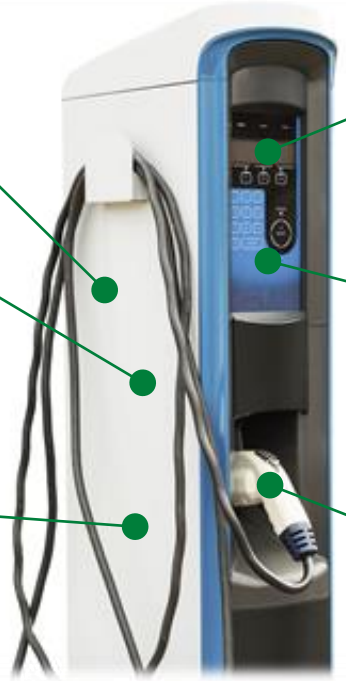
Sources: Boston Consulting Group – The Electric Car Tipping Point, 2018; Navigant Research – Market Data: Electric Vehicle Charging Equipment, 2017; Littelfuse estimates

AC charging station

Service Access Panel:
- Reed or Hall Effect Security Sensor

AC Input:
- Power Fuse Overcurrent Protection
- Fuse Block Mounting Accessory

Auxiliary Power Supply:
- Cartridge Fuse Overcurrent Protection
- TMOV/MOV, GDT Surge Protection
- SMPS Buck/Boost Module
- SMPS Opto-isolator Feedback Control
- SMPS Diode/Rectifier
- TVS Diode Overvoltage Protection
- PPTC Resettable Overcurrent Protection
- NTC Thermistor Temperature Sensing



Protect Control Sense

User Interfaces:
- TVS Diode Overvoltage Protection
- Diode Array/Polymer ESD Suppressor

Communications:
- NFC Analog Front-End
- Diode Array/Polymer ESD Suppressor

Charging Plug:
- NTC Thermistor or RTD Temperature Sensing

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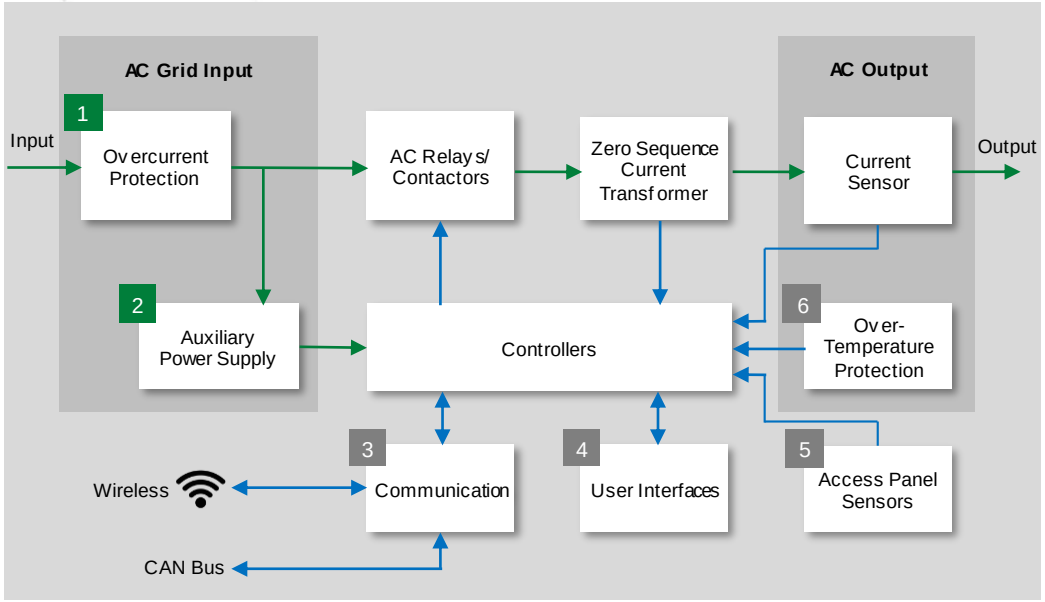
AC charger functional block diagram



	Technology	Product Series
1	AC Fuse	JLLS, JLLN, KLKD
	Fuse Block/Holder	LFT, LPSM
2	AC Fuse (PCB level)	314, 324, 215, NANO²®
	Metal-Oxide Varistor	AUMOV, TMOV, UltraMOV
	Gas Discharge Tube	CG2, CG3
	TVS Diode	AK3, AK6, AK10, LTKAK6, LTKAK10
	SIDACtor® Protection Thyristor	Pxxx0ME, Pxxx0FNL
	Silicon-Controlled Rectifier (active rectification)	SJ
	Diode (passive rectification)	DPG, VBExx, DST, DSA, DSB
	TVS Diode	P6SMB, SMBJ
	Resettable PPTC	miniSMD
	MOSFET	Polar™ Power, CPC37xx
	Optical Isolator	LOC11x, LIA1xx

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

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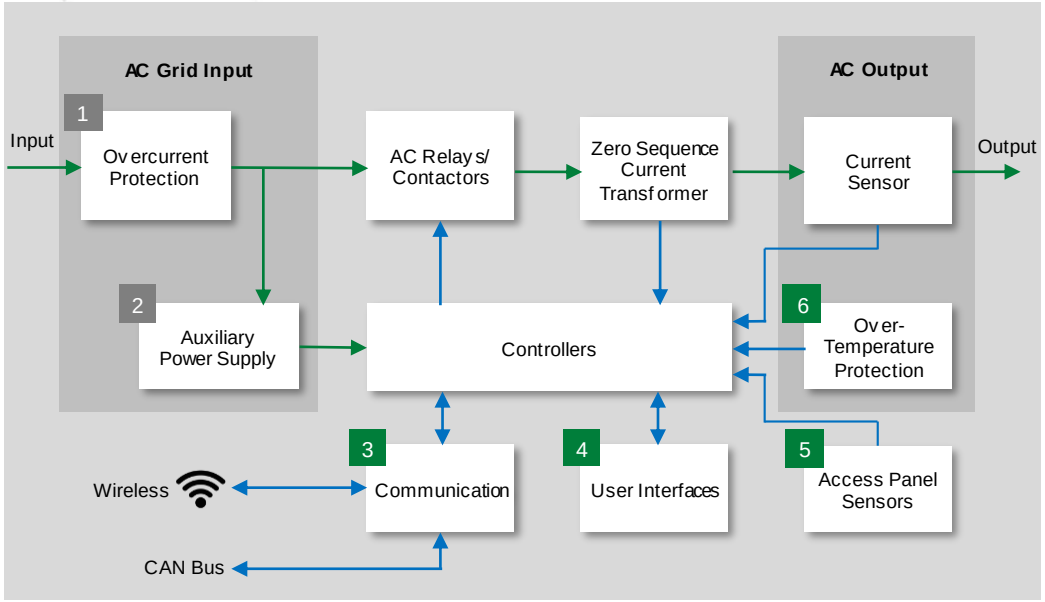
AC charger functional block diagram



	Technology	Product Series
3	NFC Analog Front-End	NCD1300
	Diode Array	AQ24CAN, SM24CANx
4	TVS Diode	SMF, SMAJ, SAC
	Diode Array Polymer ESD	SEP0xx, SP402x XGD
5	Magnetic Sensor	59060, 59135, 55075, 55100
6	Temperature Sensor	setP™, PPG, USW, Glass Coated Thermistor

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

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DC charging station

Service Access Panel:
- Reed or Hall Effect Security Sensor

User Interfaces:
- TVS Diode Overvoltage Protection
- Diode Array/Polymer ESD Suppressor

Communications:
- NFC Analog Front-End
- Diode Array/Polymer ESD Suppressor

Power Module:
- Cartridge Fuse Overcurrent Protection
- TMOV/MOV, GDT, TVS Diode, SIDACtor Surge Protection
- Rectifier Module Power Conversion
- IGBT Power Conversion
- Si or SiC MOSFET Power Conversion
- Gate Driver Control
- Si or SiC Diode Power Conversion
- NTC Thermistor Temperature Sensor

Protect Control Sense

Electrical Distribution:
- Power Fuse Overcurrent Protection
- Fuse Block Mounting Accessory
- Earth-Fault Protection Relay
- Current Transformer Leakage Current Sensing

Auxiliary Power Supply:
- Cartridge Fuse Overcurrent Protection
- TMOV/MOV, GDT Surge Protection
- SMPS Buck/Boost Module
- SMPS Opto-isolator Feedback Control
- SMPS Diode/Rectifier
- TVS Diode Overvoltage Protection
- PPTC Resettable Overcurrent Protection
- NTC Thermistor Temperature Sensing

Charging Plug:
- NTC Thermistor or RTD Temperature Sensing

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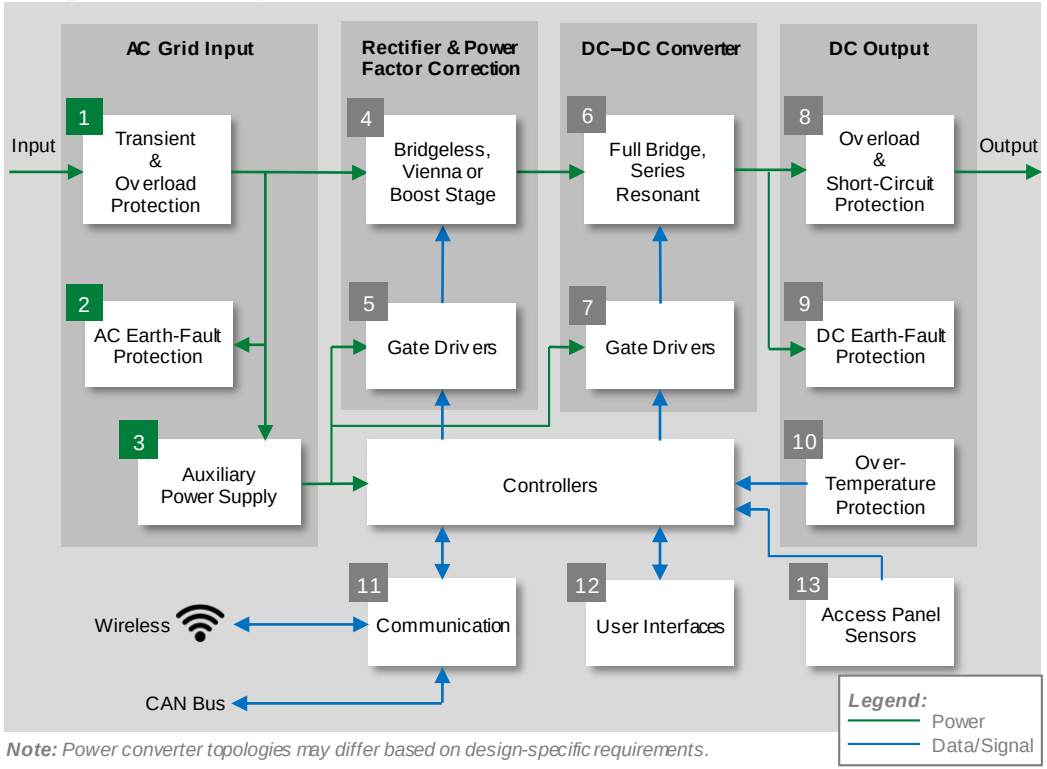
DC charger functional block diagram



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

	Technology	Product Series
1	AC Fuse (cabinet level)	JLLS, JLLN, LCD
	AC Fuse (PCB level)	606, 504, 505, 314, 215, NANO²®
	Gas Discharge Tube	CG2, CG3
	Metal-Oxide Varistor	AUMOV, TMOV, UltraMOV
	TVS Diode	AK3, AK6, AK10, LTKAK6, LTKAK10
	SIDACtor® Protection Thyristor	Pxxx0ME, Pxxx0FNL
2	Current Transformer	SE-CS30
	AC Earth-Fault Relay	SE-704
3	Silicon-Controlled Rectifier	SJ
	MOSFET	X-Class , X2-Class
	Optical Isolator	LOC11x, LIA1xx
	TVS Diode	P6SMB
	Resettable PPTC	miniSMD

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

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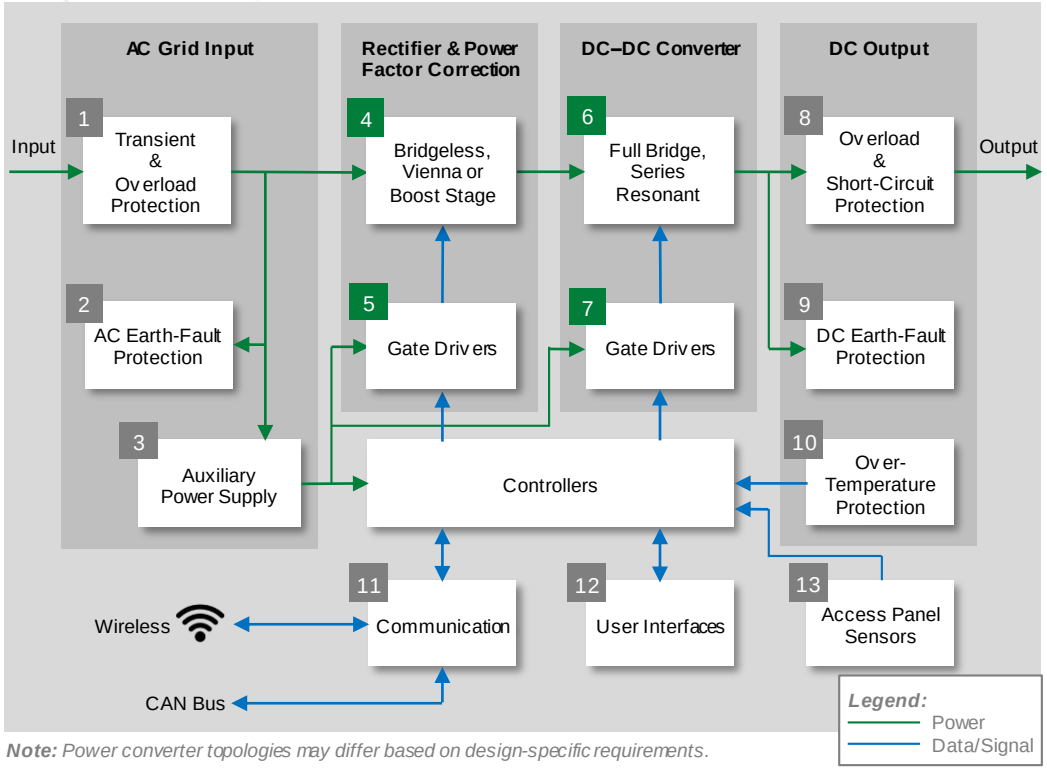
DC charger functional block diagram

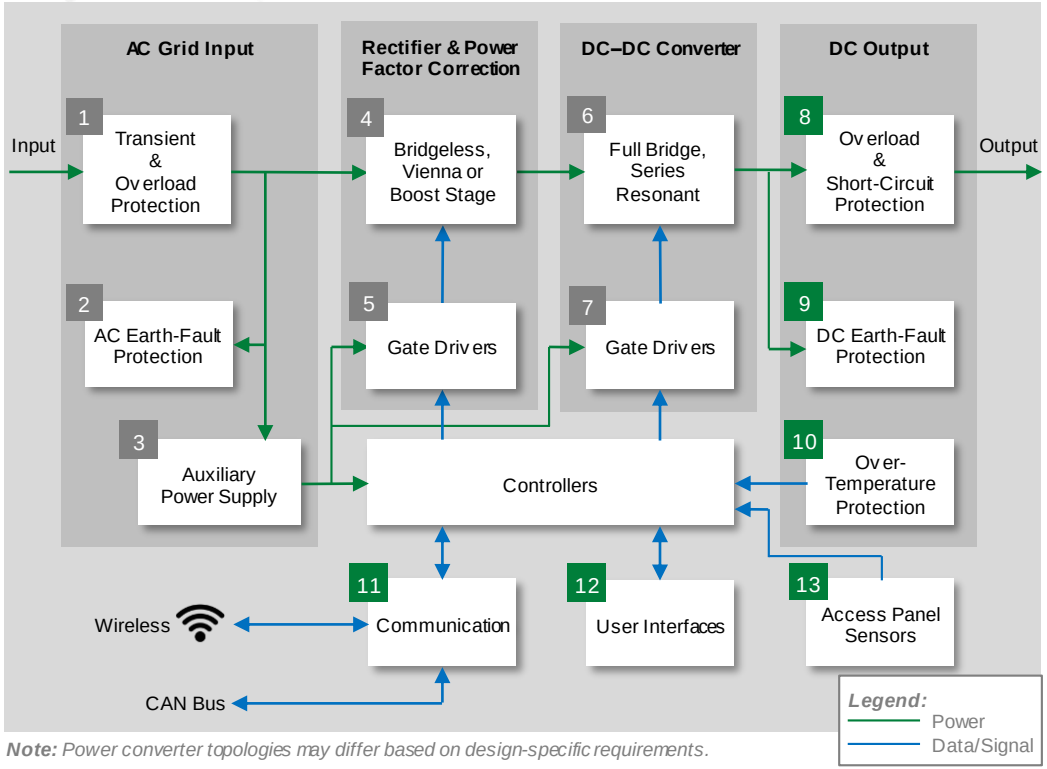


Note: *Power converter topologies may differ based on design-specific requirements.*

	Technology	Product Series
4	Bridge Rectifier	DMA200X1600NA, MDNA240U2200ED
	SiC or Si MOSFET	LSIC1MO, X2-Class Ultra Junction
	IGBT	XPT™, MIXA, MIXG
	TVS Diode	TPSMx
	Diode	LSIC2SD, SONIC-FRD™, FRED DSE
	Temperature Sensor	setP™, USUR1000, Epoxy Coated Thermistor
	High-Speed DC Fuse	L50QS, L70QS, L75QS, PSR
5	Gate Driver	IXDN604, IX4340N, IX332B
6	SiC or Si MOSFET	LSIC1MO, MCB60P1200TLB, X2-Class Ultra Junction
	TVS Diode	TPSMx
	Diode	LSIC2SD, DCG SiC Diode Module, HiPerFRED™
	Temperature Sensor	setP™, USUR1000, Epoxy Coated Thermistor
7	Gate Driver	IXDN609, IX2113, IX332B

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

DC charger functional block diagram



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

	Technology	Product Series
8	DC Fuse	L50QS, L70QS, L75QS, PSR, 505, 525
	Output "ORing" Diode	LSIC2SD, SONIC-FRD™, FRED DSE
9	DC Earth-Fault Relay	SE-601
	Earth Reference Module	SE-GRM
10	Temperature Sensor	setP™, PPG, USW, Glass Coated Thermistor
11	NFC Analog Front-End	NCD1300
	Diode Array	AQ24CAN, SM24CANx
12	TVS Diode	SMF, SMAJ, SAC
	Diode Array Polymer ESD	SEP0xx, SP402x XGD
13	Magnetic Sensor	59060, 59135, 55075, 55100

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

Wireless charging system

Power Module:

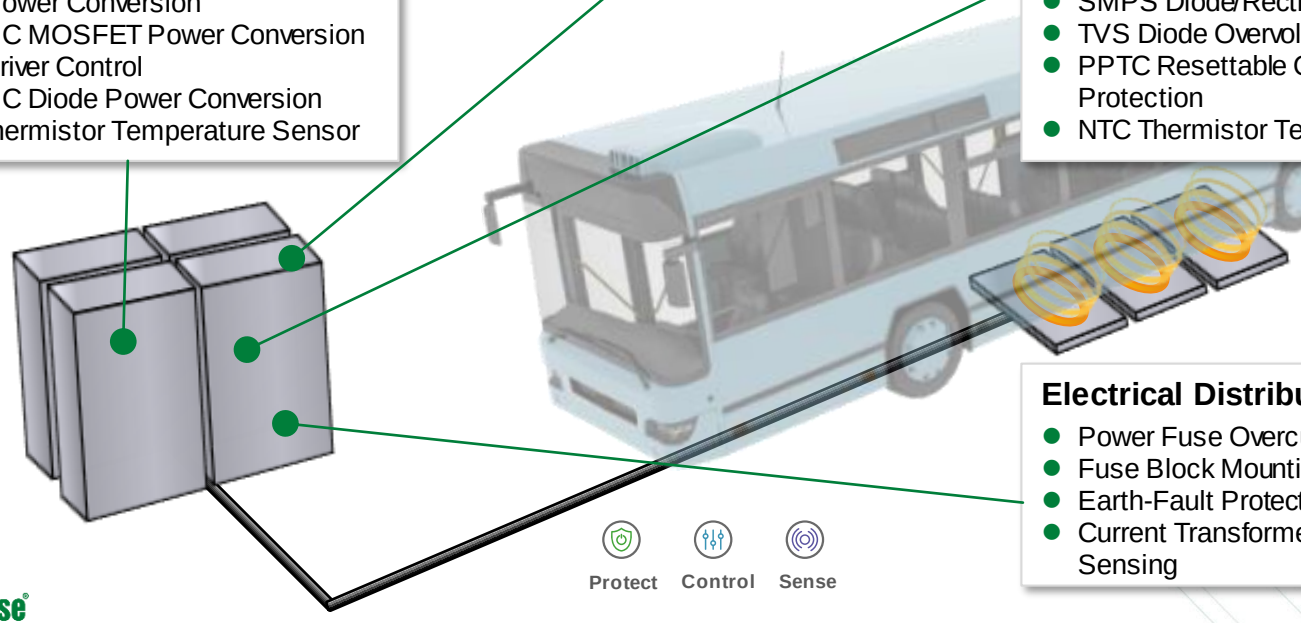
- Cartridge Fuse Overcurrent Protection
- TMOV/MOV, GDT, TVS Diode, SIDACtor Surge Protection
- Rectifier Module Power Conversion
- IGBT Power Conversion
- Si or SiC MOSFET Power Conversion
- Gate Driver Control
- Si or SiC Diode Power Conversion
- NTC Thermistor Temperature Sensor

Service Access Panel:

- Reed and Hall Effect Security Sensor

Auxiliary Power Supply:

- Cartridge Fuse Overcurrent Protection
- TMOV/MOV, GDT Surge Protection
- SMPS Buck/Boost Module
- SMPS Opto-isolator Feedback Control
- SMPS Diode/Rectifier
- TVS Diode Overvoltage Protection
- PPTC Resettable Overcurrent Protection
- NTC Thermistor Temperature Sensing



Electrical Distribution:

- Power Fuse Overcurrent Protection
- Fuse Block Mounting Accessory
- Earth-Fault Protection Relay
- Current Transformer Leakage Current Sensing

Protect Control Sense

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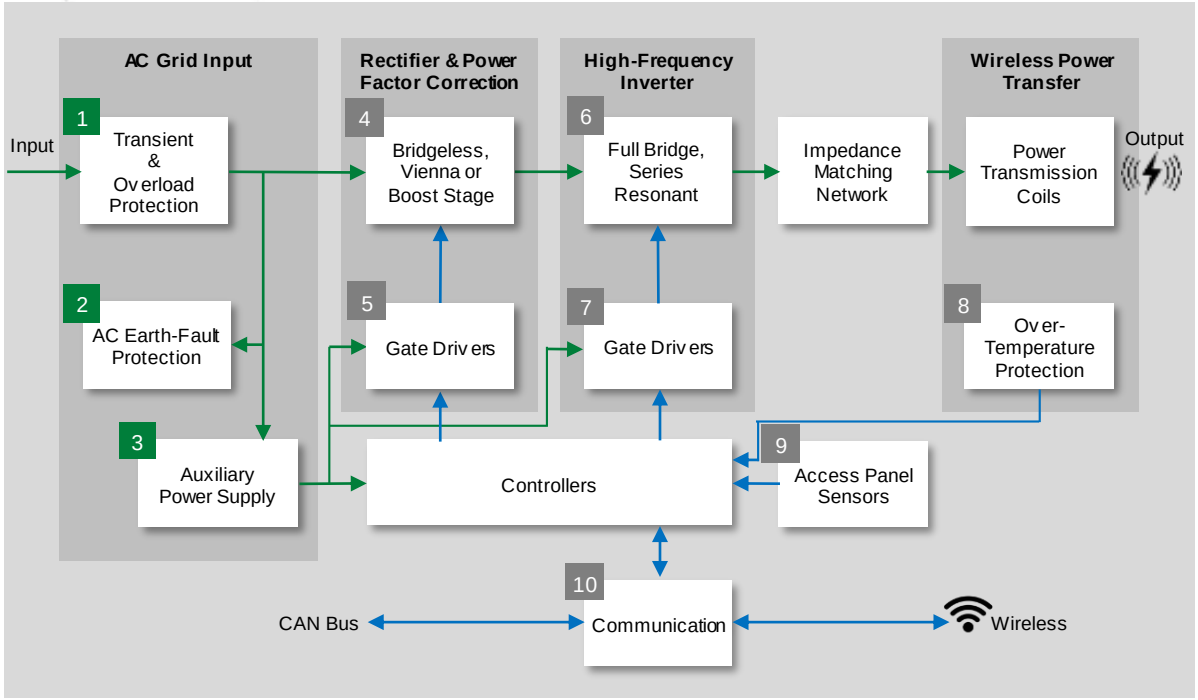
Wireless charger functional block diagram



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Legend:
Power
Data/Signal

	Technology	Product Series
1	AC Fuse (cabinet level)	JLLS, JLLN, LCD
	AC Fuse (PCB level)	606, 504, 505, 314, 215, NANO²®
	Gas Discharge Tube	CG2, CG
	Metal-Oxide Varistor	AUMOV, TMOV, UltraMOV
	TVS Diode	AK3, AK6, AK10, LTKAK6, LTKAK10
	SIDACtor® Protection Thyristor	Pxxx0ME, Pxxx0FNL
2	Current Transformer	SE-CS30
	AC Earth-Fault Relay	SE-704
3	Silicon-Controlled Rectifier	SJ
	MOSFET	X-Class , X2-Class
	Optical Isolator	LOC11x, LIA1xx
	TVS Diode	P6SMB
	Resettable PPTC	miniSMD

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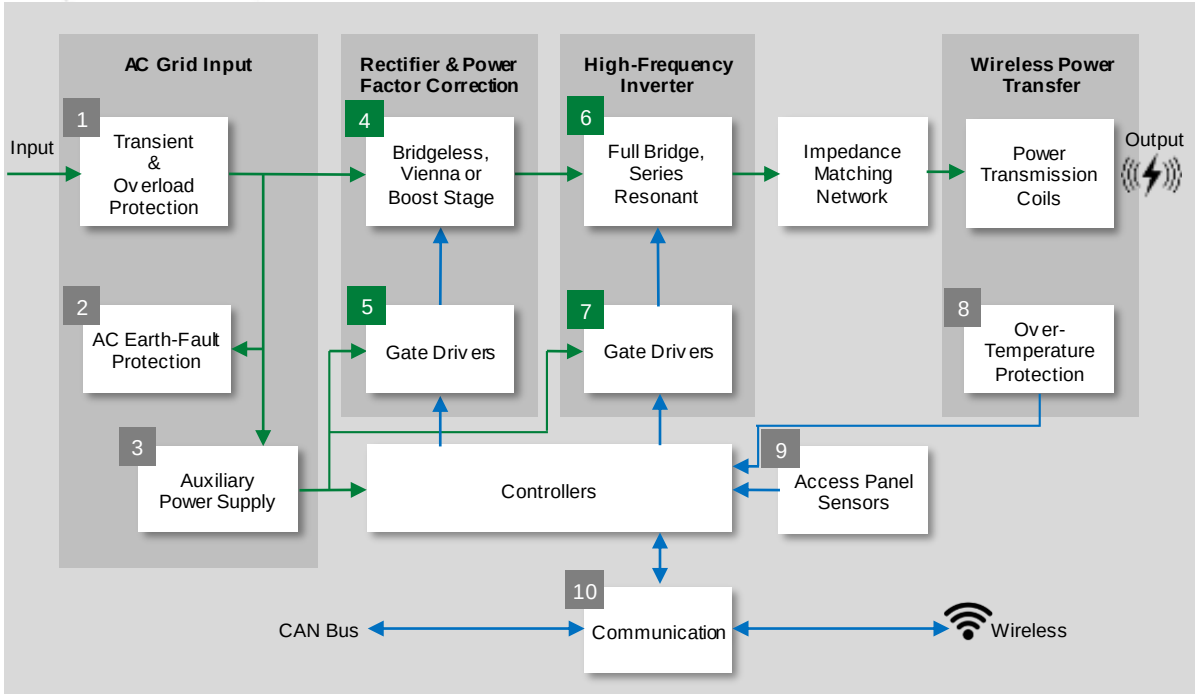
Wireless charger functional block diagram



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

Legend:
Power
Data/Signal

	Technology	Product Series
4	TVS Diode	TPSMx
	Bridge Rectifier	DMA200X1600NA, MDNA240U2200ED
	SiC or Si MOSFET	LSIC1MO, X2-Class Ultra Junction
	IGBT	XPT™, MIXA, MIXG
	Diode	LSIC2SD, SONIC-FRD™, FRED DSE
	Temperature Sensor	setP™, USUR1000, Epoxy Coated Thermistor
	High-Speed DC Fuse	L50QS, L70QS, L75QS, PSR
5	Gate Driver	IXDN604, IX4340N, IX332B
6	SiC or Si MOSFET	LSIC1MO, MCB60P1200TLB, X2-Class Ultra Junction
	TVS Diode	TPSMx
	Temperature Sensor	setP™, USUR1000, Epoxy Coated Thermistor
7	Gate Driver	IXDN609, IX2113, IX332B

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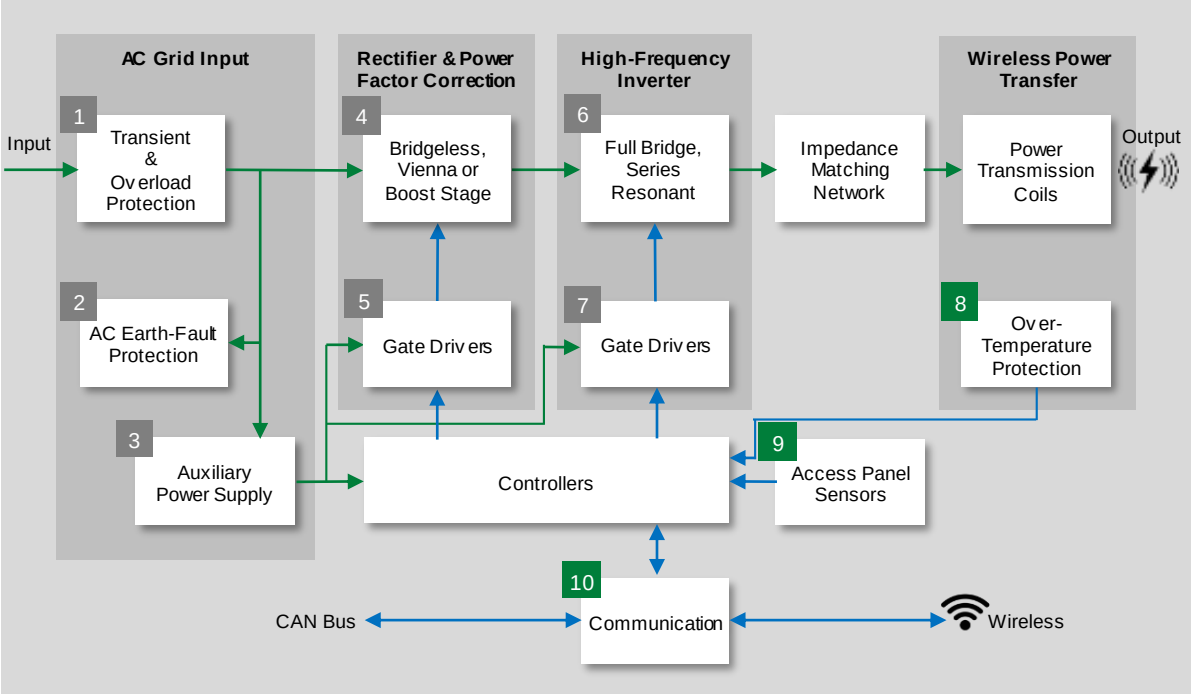
Wireless charger functional block diagram



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

Legend:
Power
Data/Signal

	Technology	Product Series
8	Temperature Sensor	setP™, PPG, USW, Glass Coated Thermistor
9	Magnetic Sensor	59060, 59135, 55075, 55100
10	Diode Array (Wired CAN)	AQ24CAN, SM24CANx
	Diode Array Polymer ESD (Wireless)	SEP0xx, SP402x XGD

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

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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	This provides 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	This provides standards for charging plugs in China.	China
JIS TS D 0007	Basic Function of Quick Chargers for Electric Vehicles	This provides standards for CHAdeMO (DC) chargers in Japan.	Japan
SAE J1772*	Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler	This provides physical, electrical, functional, and performance standards for charging plugs in North America.	North America
SAE J2954*	Wireless Power Transfer for Light-Duty Plug-In/Electric Vehicles and Alignment Methodology	This provides standards for 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	This provides safety standards for AC chargers in North America and 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	This provides safety standards for DC chargers in the United States.	United States

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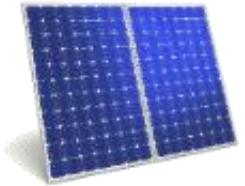
EV Charging – Technology for a Sustainable World

Uninterruptible Power Supply

Datacenter & Telecom Power Systems

Industrial Battery Charger

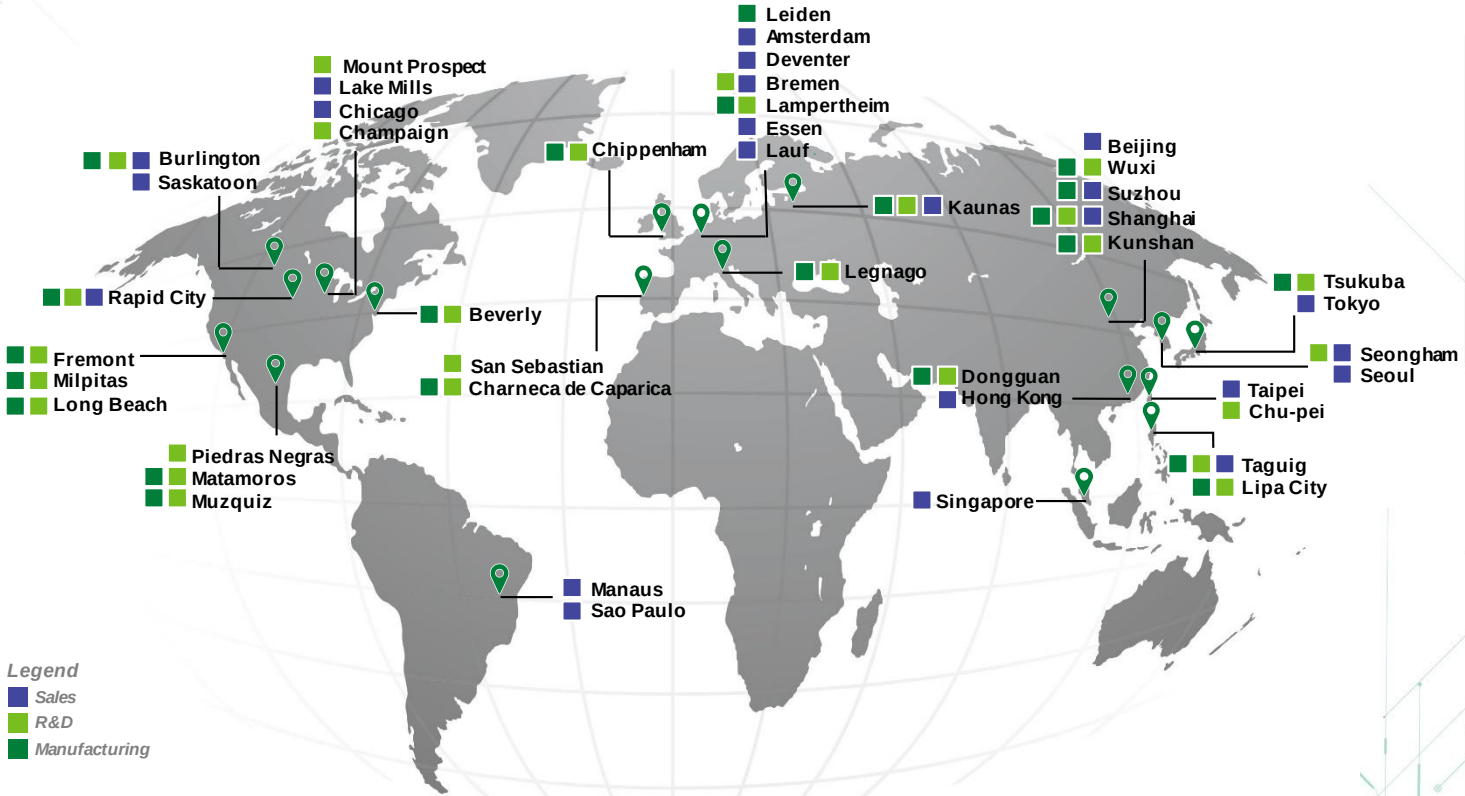


Solar Inverter & Charge Controller

Battery Energy Storage System

Wind Turbine Rectifier & Inverter

Local Resources for a Global Market



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Littelfuse Enables Enhanced Safety, Efficiency, and Reliability for Electric Vehicle Charging

Littelfuse offers:

- Reference solutions to help meet global safety requirements
- System-level design compliance support
- Components designed to help meet energy efficiency
- High-volume manufacturing with the highest quality standards

Global delivery network with localized distribution and customer support

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