Fast EV charging – Trends and system solutions

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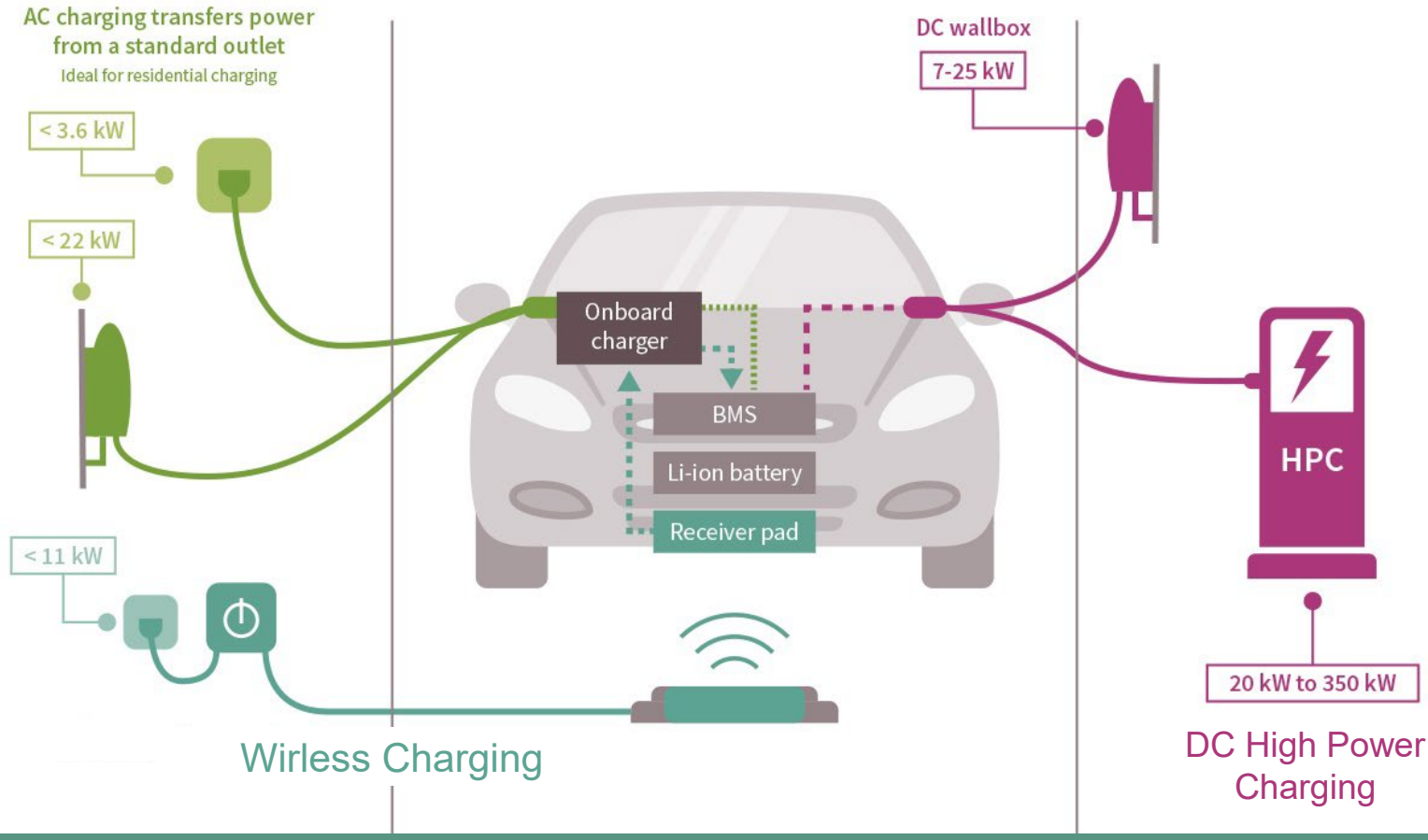
EV charging is a key strategic application for Infineon
We cover the full ecosystem from AC to high power DC charging

Connectivity solutions	Automotive systems	High power industrial systems



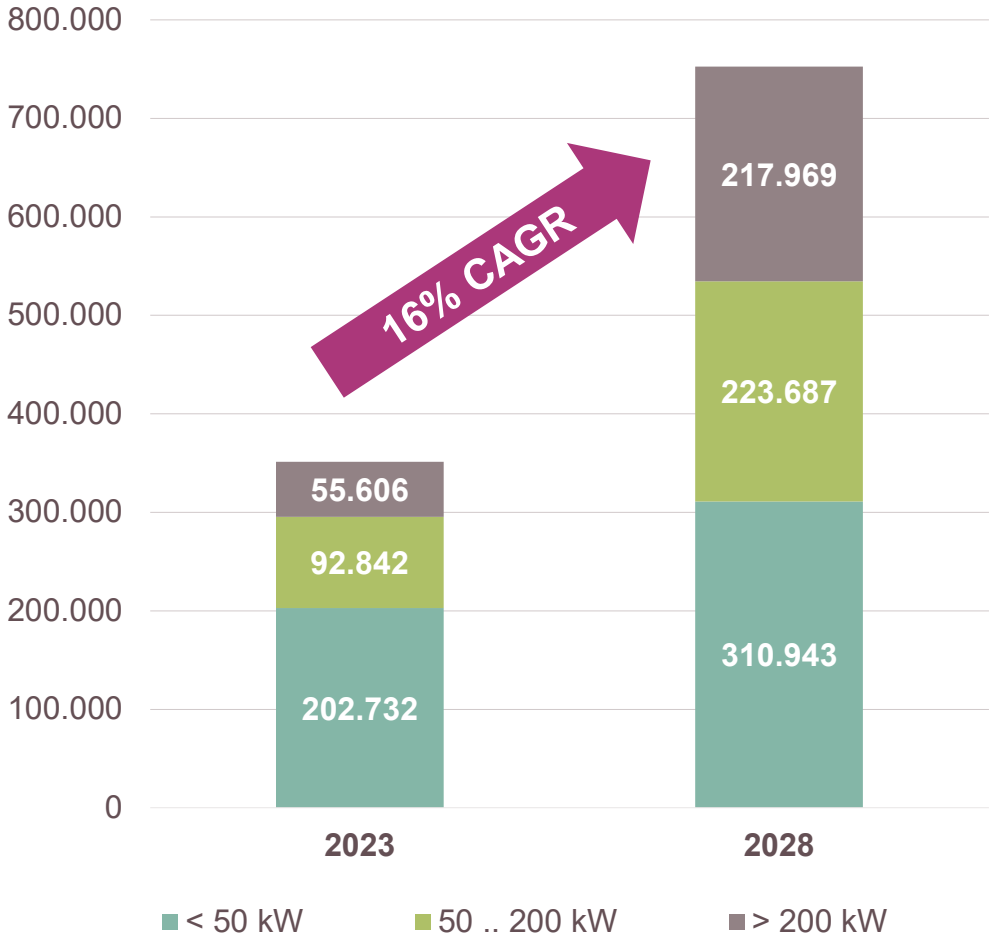
Infineon targets the complete EV charging ecosystem from AC to high-power DC

Different use cases require different types of chargers, incentives and cost positioning will drive the total market

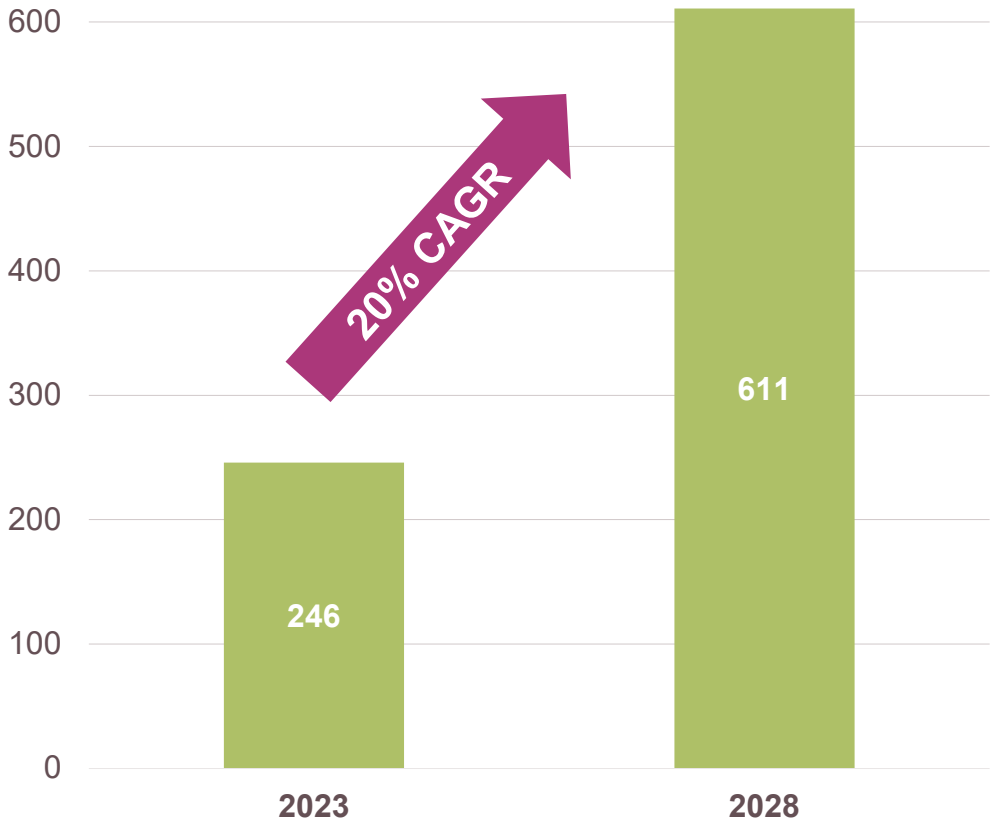
		 **Residential – AC wallbox**	 **Residential – DC wallbox**	 **Commercial mid-power charger**	 **Commercial – high-power charger**
Characteristics	**Time to charge 40kWh battery**	>2h	>2h	<1h	<20min
	Place of installation	Residential and public domains	Residential and public domains	Cities, commercial, shopping areas	Charging parks, highways
	Typical output power	7-22kW	≤22kW	22kW to 50kW	>50kW
	Bi-directionality	Yes, with On-board charger	yes	yes	yes
	Preferred power implementation	No power content in charger	Discrete power	Discrete power / Module solutions	Module solutions
	Beyond Power	Control, Security, Connectivity	Control, Secured payment, Connectivity, HMI, Sensor System	Control, Connectivity, HMI, Secured payment, Sensor System	Control, Connectivity, HMI, Secured payment, Sensor System

The addressable market is growing with ~20% CAGR
EV charging applications is an important contributor to Infineon's growth

DC EV charger market in units



Semiconductor market in US$M



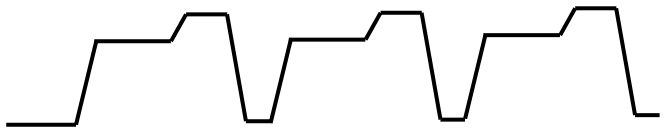
Source: DC Charging for Automotive 2023, Yole Development, 2022

EV charging trends are unique in the market, SiC enables future power trends, intelligent control & secure connectivity enables IoT trends

Today

Harsh operating modes

SiC



up-to 100k cycles / lifetime
Changing operation modes
High temperature cycles

Reliability, harsh enviroment

SiC

High system reliability

Harsh enviroment:
IP65, -45°C – 55°C

Fanless

Cooling optimization
Reducing fans improves reliability and noise(<50dB)

Gen 2

Higher efficiency
Wide voltage scalability

SiC

Higher efficiency 96% >> 98%
@ various operation modes

Wide voltage output **150V > 1000V** support with wide efficiency plaeau

High power density up-to 10kW/l enables high space utilization

High modularity and scalability

SiC

22 kW	30 kW
50 kW	75 kW
75 kW	100 kW

Easy upgradability, scalability

Gen 2+

Bi-directionality
Energy integration

SiC

Charging grid

- V2X (bi-directional)
- Energy integration

Megawatt charger

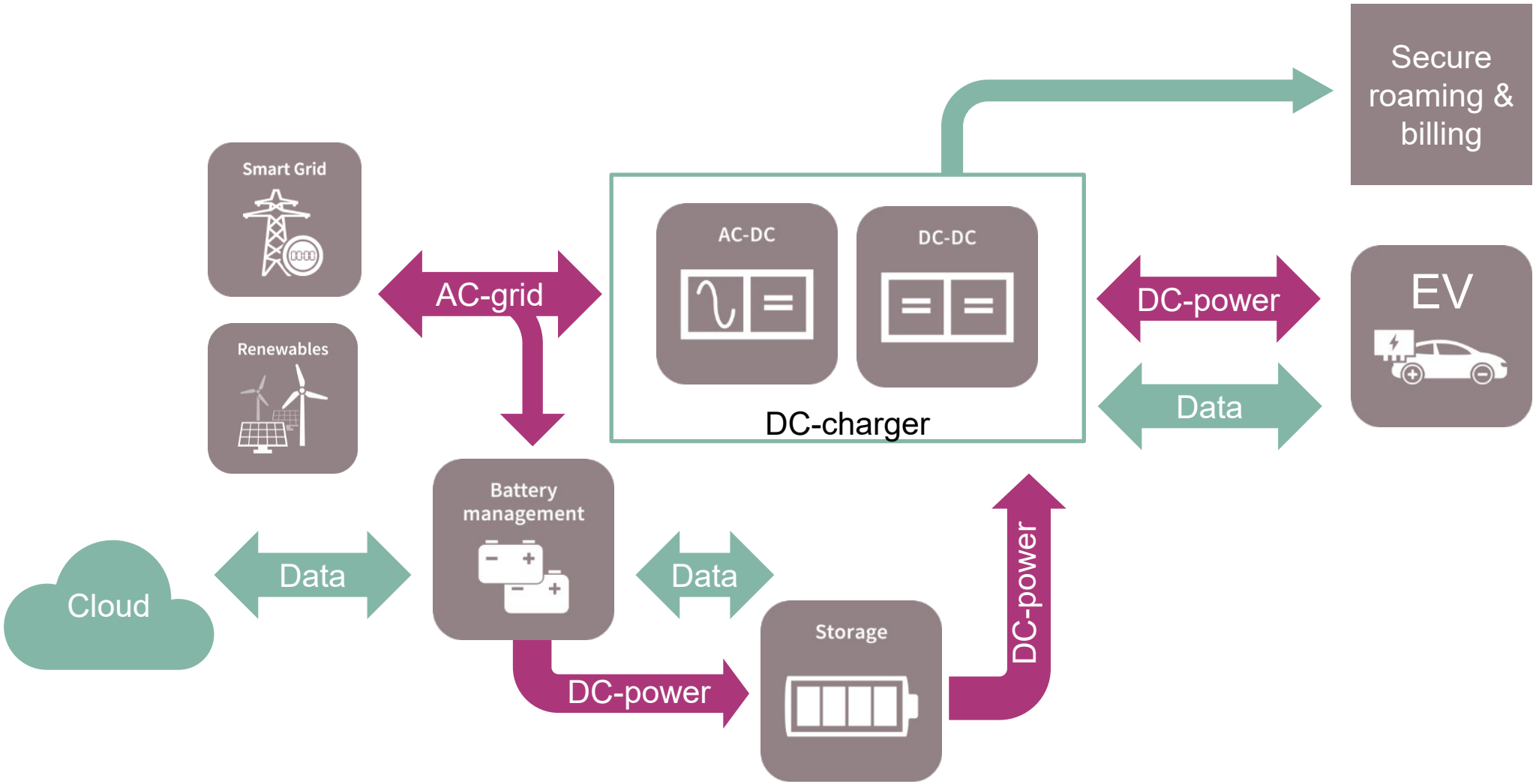
SiC

eBus

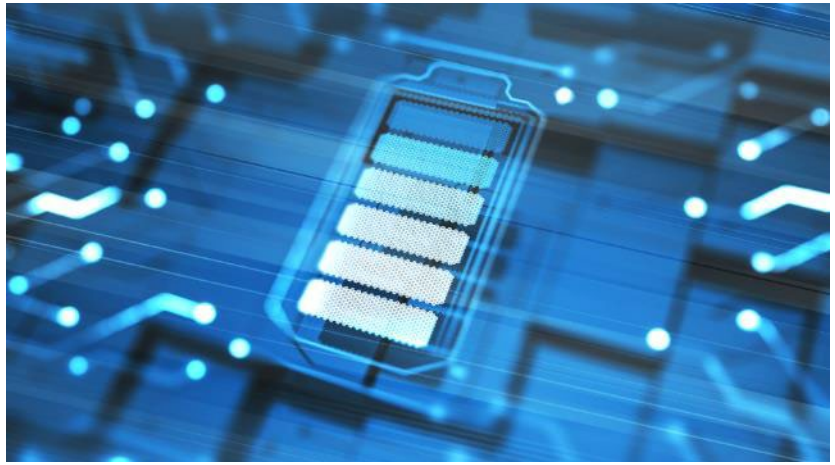
eTruck

- Higher voltages (1250V) and
- Higher currents (up-to 3000A)
- V2X (bi-directional)
- Capable of being automated

Structure of DC EV charging system



EV charging superstore
Infineon’s comprehensive product and solution offering for DC EV charging



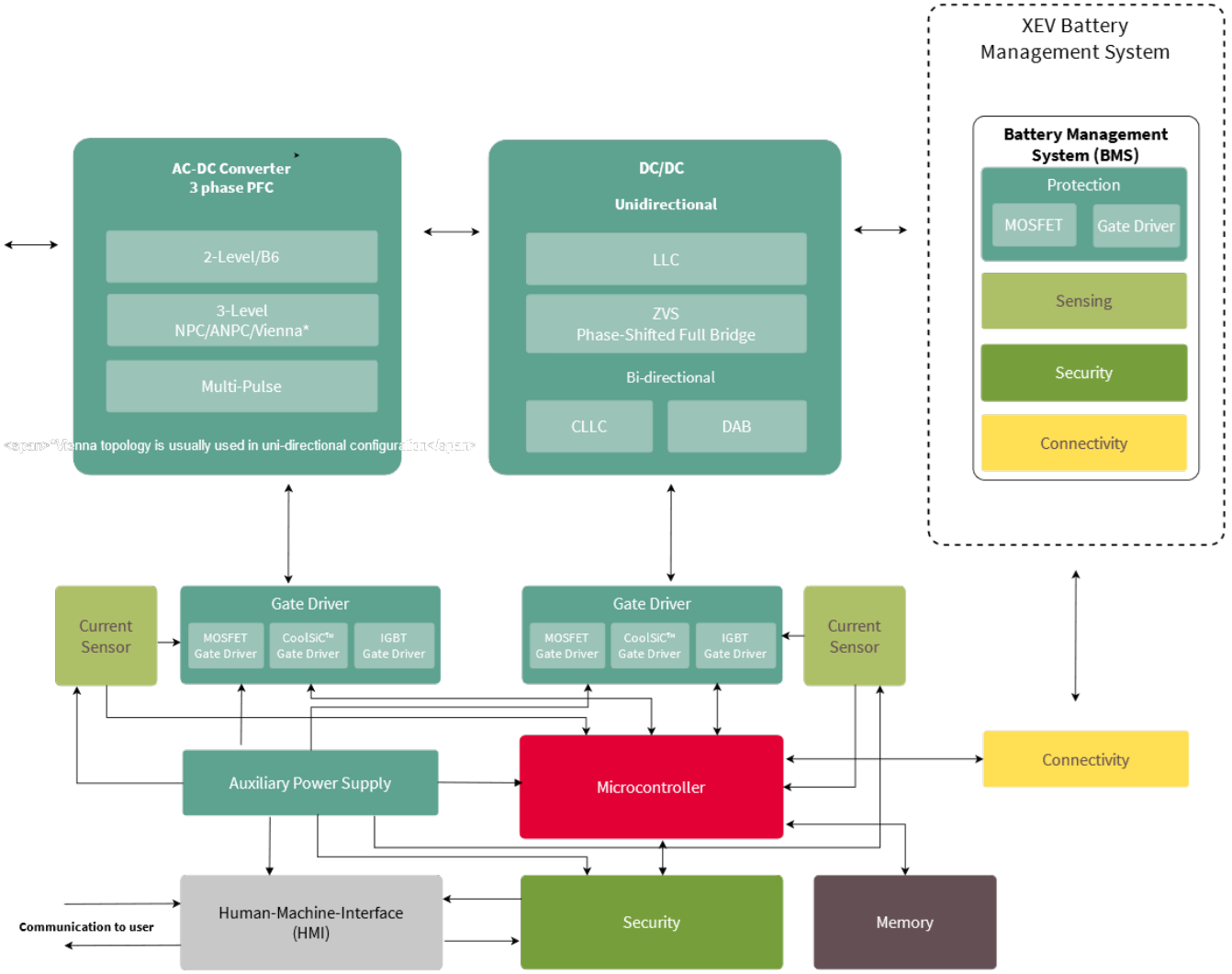
Power Density

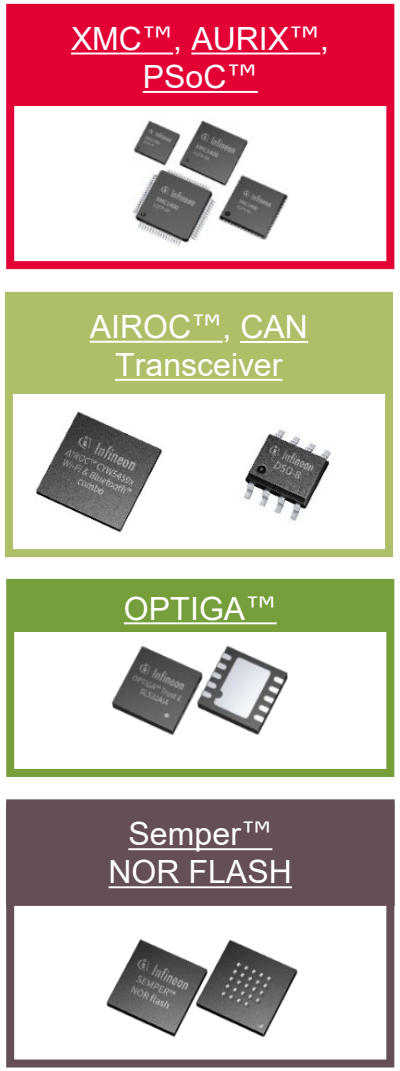
Efficiency

Sense and Communication

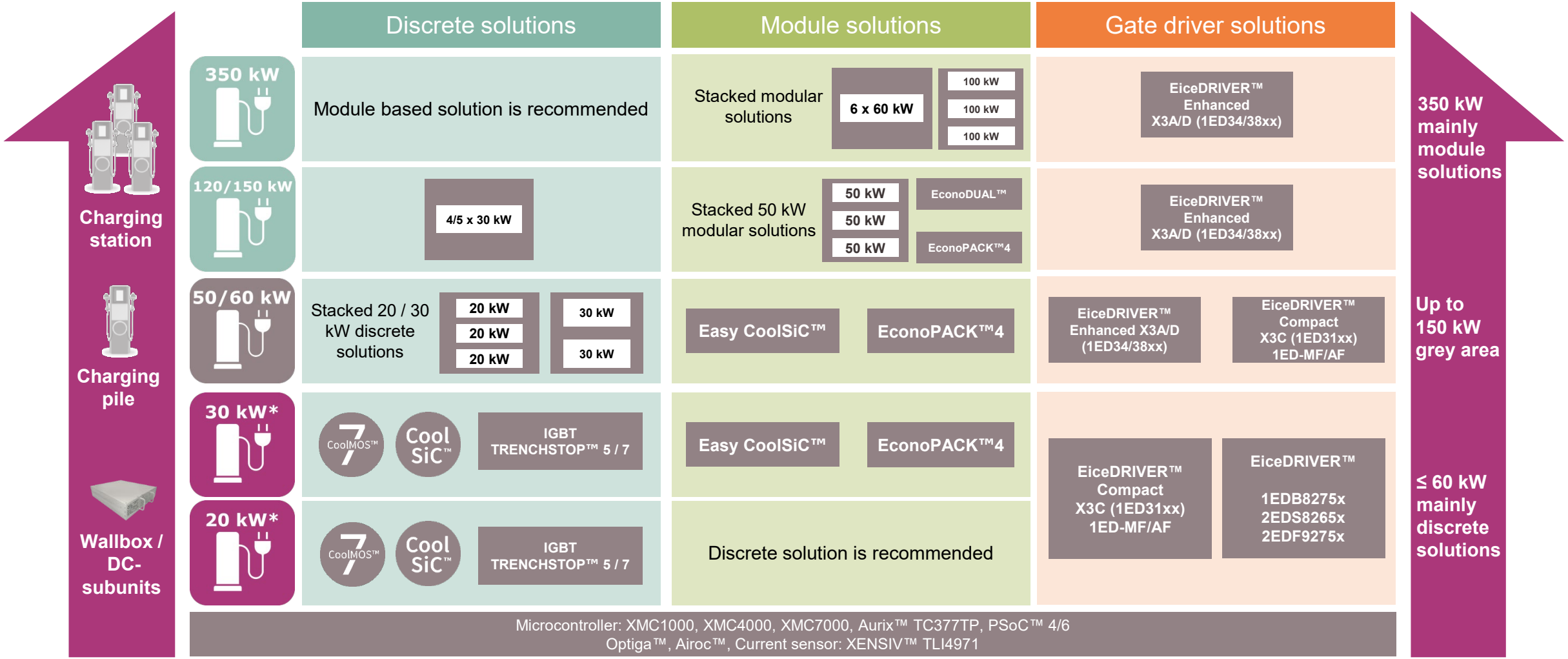
System control	Power stage	Technologies	Connectivity	Sensors	Security	External memory
› XMC™ 1000, 4000, 7000 › PSoC™ 6 › AURIX™ TC377TP	› Easy Power Modules › IGBT Discretes › EiceDRIVER™ Gate drivers for SiC MOSFETs, & IGBTs with various safety features	› CoolSiC™ › TRENCHSTOP™ IGBT7 › CoolMOS™ › CoolGaN™	› Wi-Fi and BTBLE solutions › CAN Transceiver	› Current sensors Integrated shunts & XENSIV™ TLI4971/2-A120T5-E0001	› OPTIGA™ embedded security solutions › Secured communication/ secured host firmware update OPTIGA™ Trust M	› EXCELON™, HYPERRAM™ and SEMPER™ Flash and RAM solutions

The application DC EV charger contains these key functional blocks





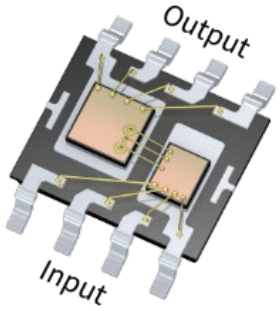
The perfect solution for every power class: Infineon's power solution positioning for DC EV charger



* DC charger subunit or DC charger

Every switch needs a driver, the right driver makes a difference
EiceDRIVER™ isolated gate driver portfolio

ED-E Enhanced



EiceDRIVER™ Enhanced

Up to 2300 V, 9 A
DESAT, Miller clamp

Rich feature-set for advanced protection:

- **F3 (1ED332x):** Cost effective solution with DESAT
- **X3 Analog (1ED34xx):** Best-in-class DESAT accuracy, analog configurability
- **X3 Digital (1ED38xx):** I2C configurable enabling predictive maintenance

www.infineon.com/gdenhanced

ED-C Compact

EiceDRIVER™ Compact

Up to 2300 V, 18 A
Miller clamp, 2-level slew-rate-control

Reduced feature-set and easy to design-in:

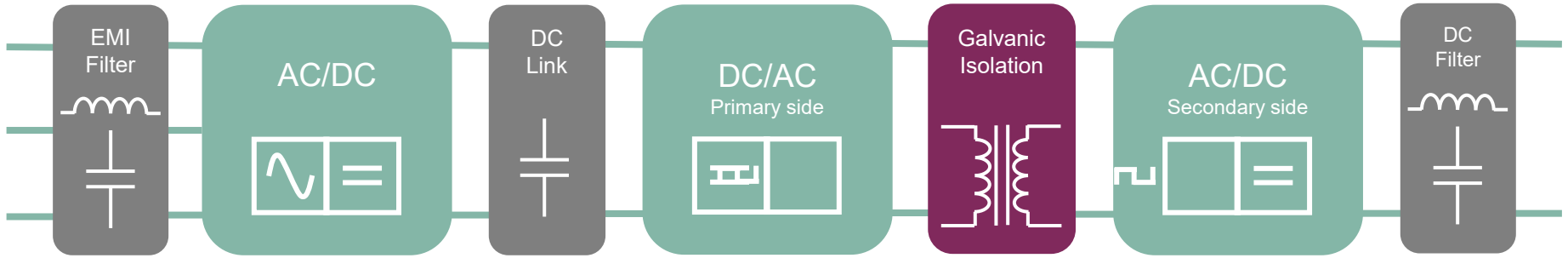
- **X3 Compact (1ED31xx):** easy to design & cost effective
- **2L-SRC Compact (1ED32xx):** EMI & switching loss optimization

New products with Reinforced isolation (UL 1577 and VDE-11)

www.infineon.com/gdcompact

Typical solutions for chargers from 30 kW to 150 kW using discrete devices

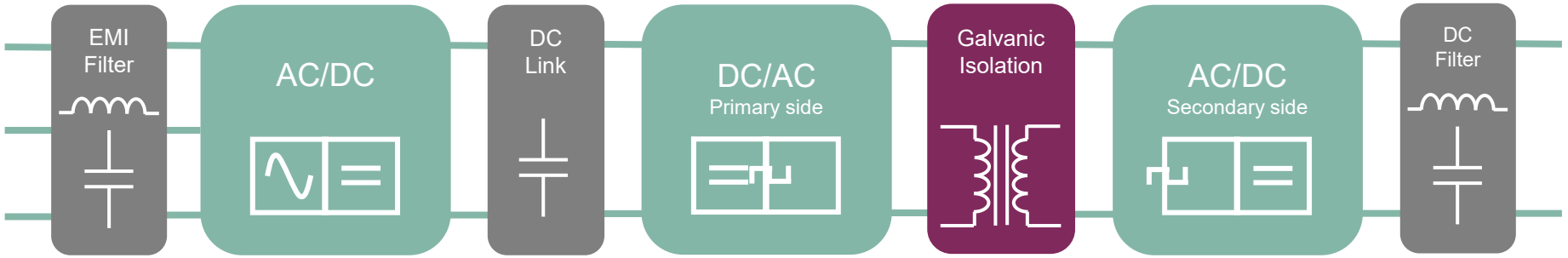
Stacking of subunits	Vienna rectifier, Active Front End (AFE) for PFC Stage	**600 V CoolMOS™ P7** 650 V IGBT TRENCHSTOP™5 1200 V CoolSiC™ Schottky Diode EiceDRIVER™ isolated gate driver
3-phase AC input		
Galvanic isolation within the subunit	Resonant converter e.g. interleaved 3-phase, Multiphase Buck Converter for DC/DC Stage	**600 V CoolMOS™ CSFD and CFD7** 1200 V CoolSiC™ MOSFET 650 V / 1200 V CoolSiC™ Schottky Diode EiceDRIVER™ isolated gate driver
Power of subunit 15-30 (50) kW		



Typical solutions for chargers from 50 to 350 kW using power modules

CoolMOS™ 7 | CoolSiC™ | IGBT TRENCHSTOP™ H5 | ED-C Compact

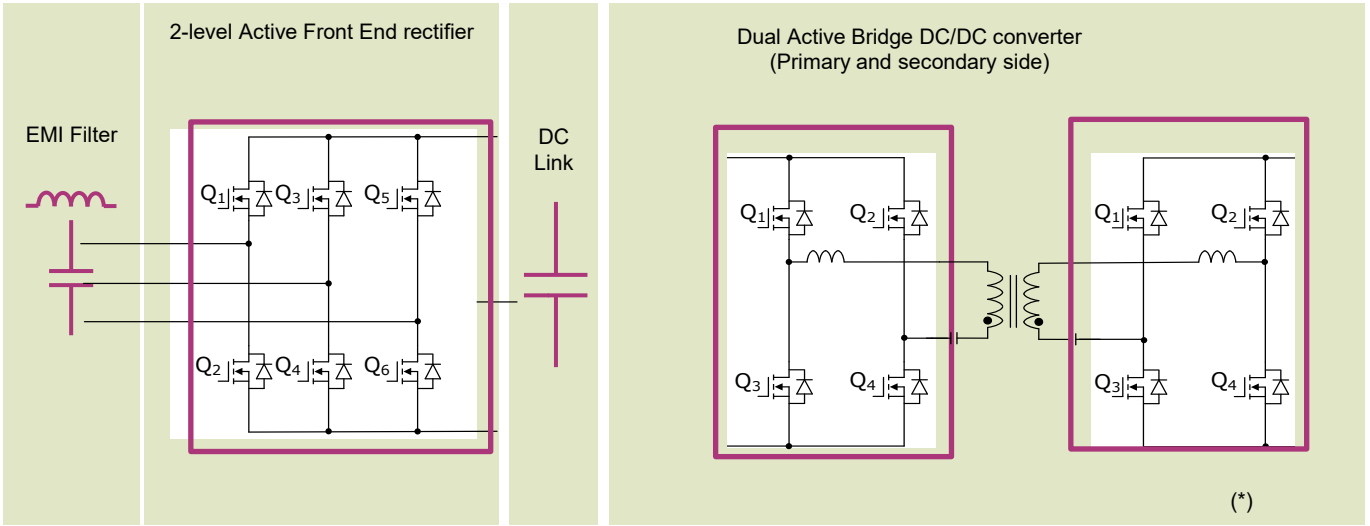
Stacking of subunits	Vienna rectifier, Active Front End (AFE) for PFC Stage	CoolSiC™ Easy Module IGBT EconoPACK™ IGBT EconDUAL™ Diode Rectifier module EiceDRIVER™ isolated gate driver
3-phase AC input		
Galvanic isolation within the subunit	Resonant converter e.g. interleaved 3-phase, Multiphase Buck Converter for DC/DC Stage	CoolSiC™ Easy Module IGBT EconoPACK™ IGBT EconDUAL™ EiceDRIVER™ isolated gate driver
Power of subunit (30) 50-75 kW		



Example power converter BOM
High efficiency 50-60 kW design (Bi-directional)

2 X FS13MR12W2M1H(P)_B11

2 x FF11MR12W2M1H(P)_B11



Stage	Switching Freq.	Devices	Product	Part number	Pcs
AC/DC	40 kHz		1200 V CoolSiC™ Easy 2B	FS13MR12W2M1H(P)_B11	2
		Driver IC	EiceDRIVER™ 1ED	1ED3124MC12H	6
		Sensor	XENSIV™ magnetic current sensor	TLI4971-A120T5	3
DC/DC	up to 300 kHz		1200 V CoolSiC™ Easy 2B	FF11MR12W2M1H(P)_B11	4
		Driver IC	EiceDRIVER™ 1ED	1ED3124MC12H	8
µC			AURIX™ microcontroller	TC377TP	1

*) Simplified schematic diagram. Symbols for the schematic diagram are only for illustration purposes and does not refer to the proposed bill of material.

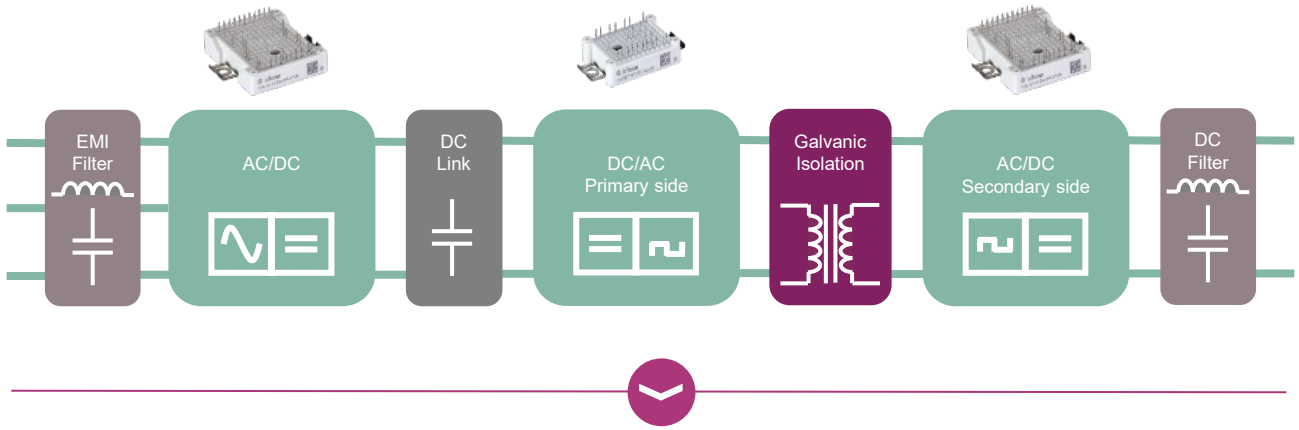
Key features and benefits

- **Bidirectional**
- Highest efficiency with CoolSiC™ technology
- BOM parts reduction
- Higher reliability
- Low design complexity
- Fast time to market

Application assumptions

- Topology: NPC2 in AC-DC stage and 3phase CLLC or DAB in DC-DC stage
- 60 kW, 120 A @ 500 V
- Liquid cooled
- Switching frequency 120 kHz for DC-DC Converter

CoolSiC™ helps to cut charging time for electric vehicles by 50%



Advantages of SiC

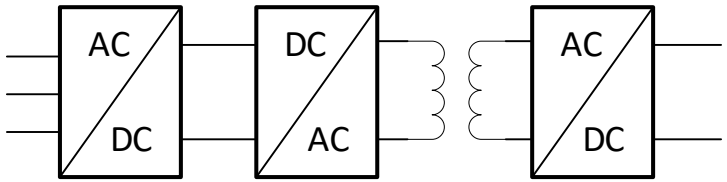
- CoolSiC™ MOSFET **reduces charging time** at the same charging station and footprint
- One 1200V CoolSiC™ MOSFET is sufficient to **support** a DC-link voltage of **800V** as well as **bi-directional operation**
- Due to 50% lower conduction and switching losses from lower C_{oss} the overall efficiency can be increased which lowers the cooling effort → **> 97% total efficiency** at full load
- High switching frequencies leads **to less noise**

SiC enables up to 2% efficiency gain in DC EV charger applications compared to Si-based solutions

SiC-enabled efficiency gain example:

DC-DC* (LLC) stage: **up to 1%**

AC-DC** stage: additional **up to 0.8%**



∑ ~1.8% total system efficiency gain by changing from Si to SiC

~33% higher power density

- Smaller designs and less weight, e.g. for DC wallbox application
- Higher power utilization within the same space ➔ faster charging

Less cooling effort

- Less active cooling, fewer mechanical components ➔ increased reliability
- Lower noise level for usage in residential areas

Energy cost and CO_2 savings

~2% efficiency = 2 kWh energy saving for 100 kW charging power:
- ~550 € energy cost savings annually*
- ~7 tons of CO_2 savings annually*

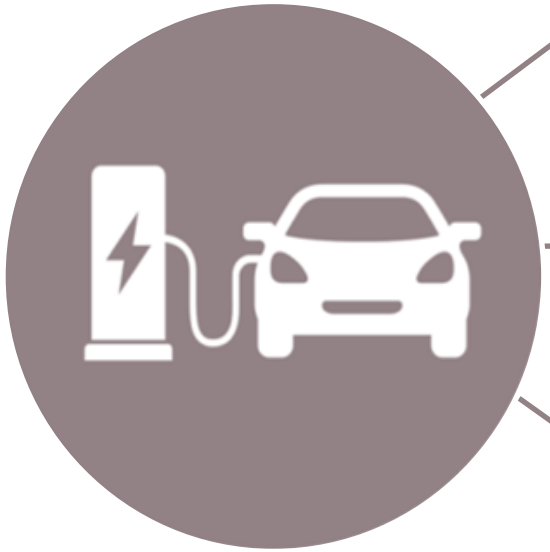
* @ AVG 10h operation/day & 0.15€/kWh electricity costs

* LLC 30kW Si vs. SiC
** e.g. Vienna rectifier SiC- vs. Si-Diode efficiency measurement

Infineon products addressing EV charging needs beyond power

MCU	Secure Connectivity	Sensors	Isolation	Memory
PSoC™ 4: Most flexible and scalable low power mixed-signal architecture › Cortex®-M0+ cores combined with mixed-signal hardware IP & CapSense™	**AIROC™ Wi-Fi + Bluetooth Combos** › 802.11a/b/g/n/ac/ax Wi-Fi and Bluetooth® 5.2 in a single-chip solution › Can be coupled with external MCUs via RTOS, along with Linux on MPUs	**XENSIV™ Current Sensors** › Minimal insertion inductance (220 µW & resistance <1 nH) › High dynamic range, high peak current › Thermal performance › Fast OCD › Small size	**ISOFACE™ Digital Isolators** › 2-channel and 4-channel Digital Isolators for functional and safety isolation with highest robustness, accurate timing performance and low power consumption	**EXCELON™ F-RAM** › Read/write endurance of 100 trillion cycles to log data continuously › Low pin count, 108 MHz QSPI interface that is as fast as a parallel interface
PSoC™ 6: Purpose-Built for the IoT › Combining Cortex®-M4 and Cortex®-M0+, industry-leading ultra-low power, flexibility & security for the IoT	**AIROC™ Bluetooth & Multiprotocol SoCs** › Bluetooth Classic, BLE and BLE Mesh solutions	**XENSIV™** › MEMS microphones › Magnetic, Pressure, CO_2 , Radar or ToF 3D image sensors		**HYPERRAM™** › High read/write (800 MBps) bandwidth for maximum system performance › Low pin count, small form factor for system cost savings › Hybrid sleep mode and partial array refresh for low power
XMC™ Industrial Microcontroller › Real-time control with application specific peripheral	**OPTIGA™ Trust** › Offering rock-solid hw security for IoT devices › Pre-provisioned with easy cloud onboarding			**SEMPER™ NOR Flash** › Market leadership with the world's most safe, secure, and reliable NOR solutions
AURIX™ 32bit TriCore™ Microcontroller › The AURIX™ family with its embedded safety and security features is the ideal platform for a wide range of automotive and industrial applications	**OPTIGA™ Connect** › Turnkey eSIM security solutions			

Infineon reference designs for different DC EV charging systems



Home

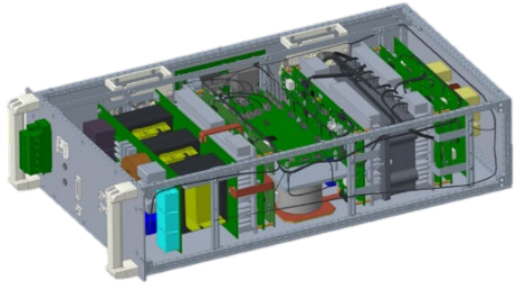
Public

Highway

11 kW bi-directional DC-DC converter:
REF-DAB11KIZSICSYS

22 kW DC wallbox: in development

up to **50 kW DC charger subunit**
for high power charging systems:

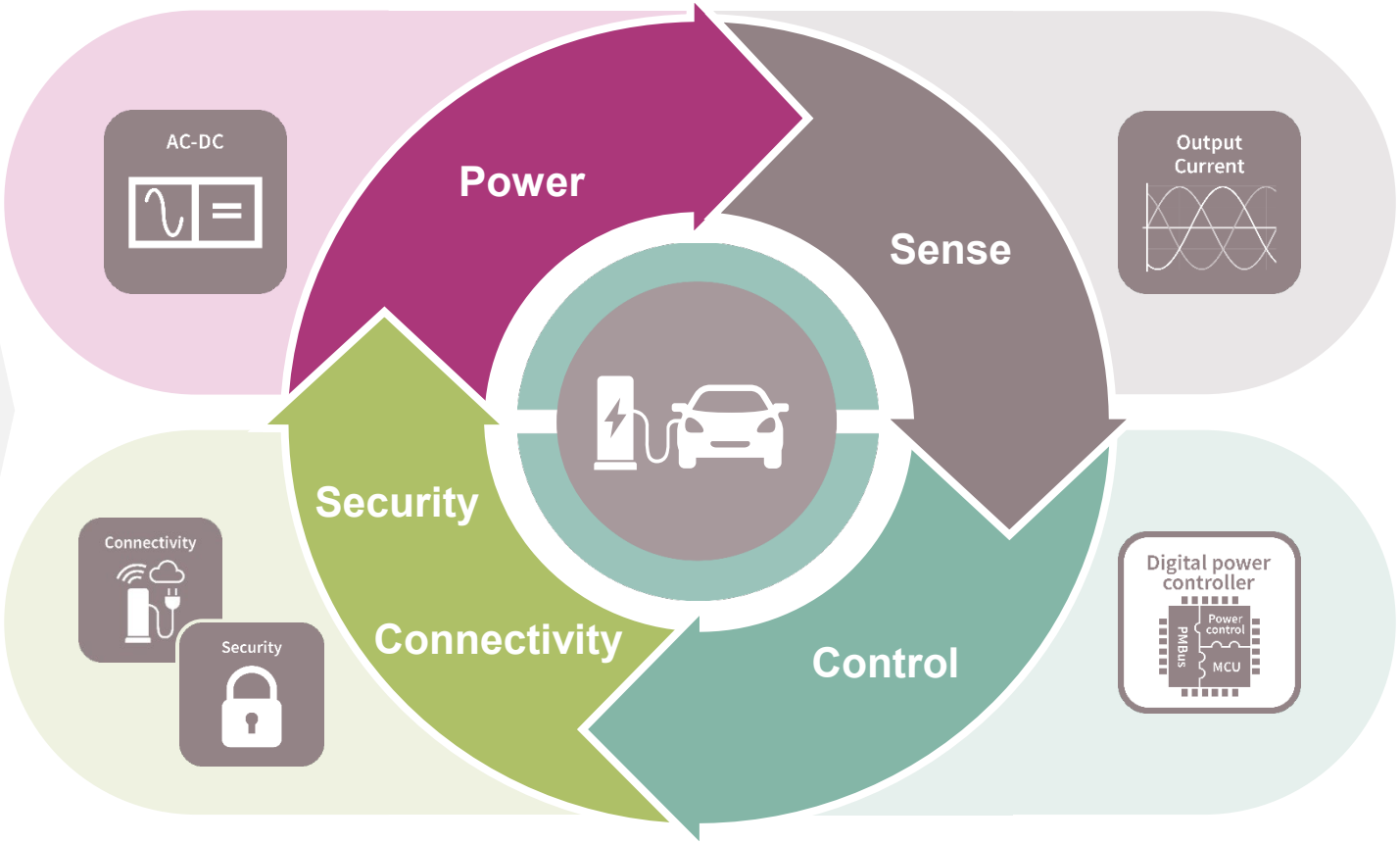


Release planned for Q3 - 2023

EV charging application trends, requirements, and designs are supported by Infineon's comprehensive solution offerings

REQUIREMENTS/ TRENDS

- Energy efficiency
- Bi-directionality
- Power density
- Scalability



Reference designs

Visit www.infineon.com/ev-charging for more information

Supporting material for Infineon's EV charging offering

Application pages

- Fast EV Charging
- Chargers up to 150 kW
- Chargers from 50 kW to 350 kW
- DC wallbox

Collaterals and brochures

- Application presentation
- Application brochure
- Whitepaper I
- Whitepaper II
- Product selection guide
- Product presentation
- Articles

Simulation tools

- IPOSIM

Evaluation boards

- Boards fast EV charging
- Boards chargers up to 150 kW
- Boards chargers from 50 kW to 350 kW

Videos / podcasts/ trainings

- Videos
- Podcast
- Trainings

Part of your life. Part of tomorrow.