Mobile Robots: Charger

AGV – Automated Guided Vehicles
AMR – Automated Mobile Robots

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Application Manager Robotics

2022 Edition

Infineon is a globally leading semiconductor player

* over the cycle 9%+ revenue growth; 19% Segment Result margin; investment-to-sales ratio of 13%;
targets to be approached as integration progresses

top 10

› semiconductor company

~46,700

› total employees

~7,800

› R&D employees

leading player

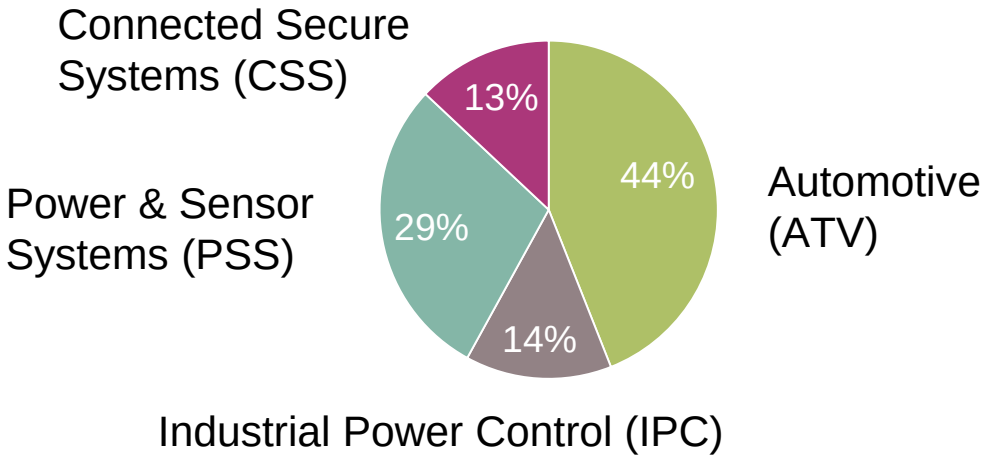
› in automotive, systems for power management and drives, sensor systems, connected secure systems, wireless combos, differentiated memories

9%+ I 19% I 13%

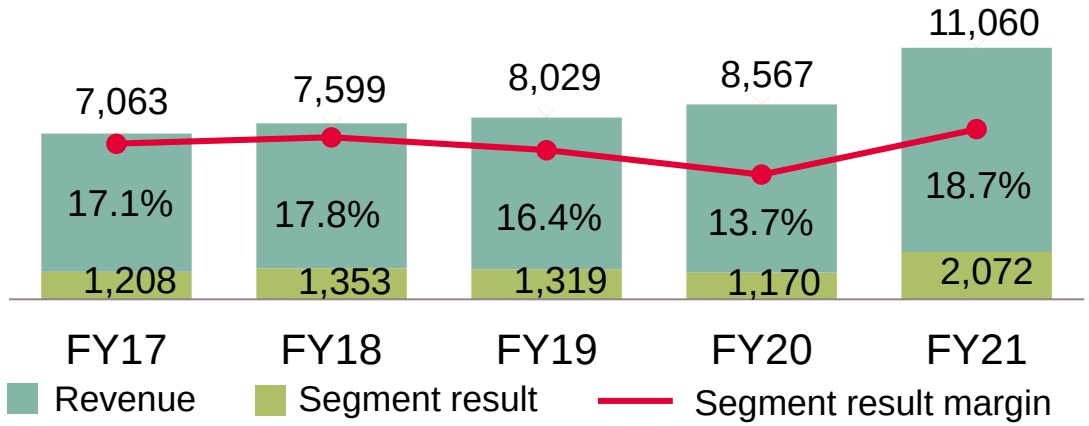
› target operating model*

Infineon at a glance

Business segments revenue*



Financials

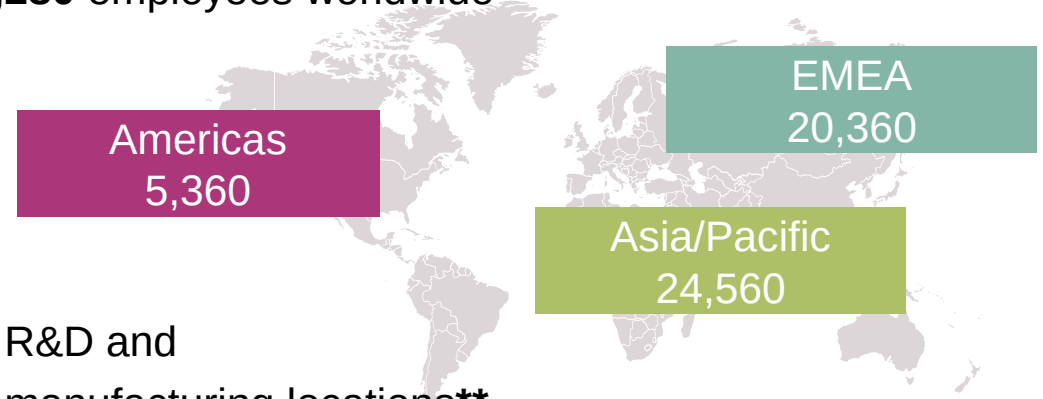


*2021 Fiscal year (as of 30 September 2021)

**as of 30 September 2021

Employees*

50,280 employees worldwide



56 R&D and

20 manufacturing locations**

Market position

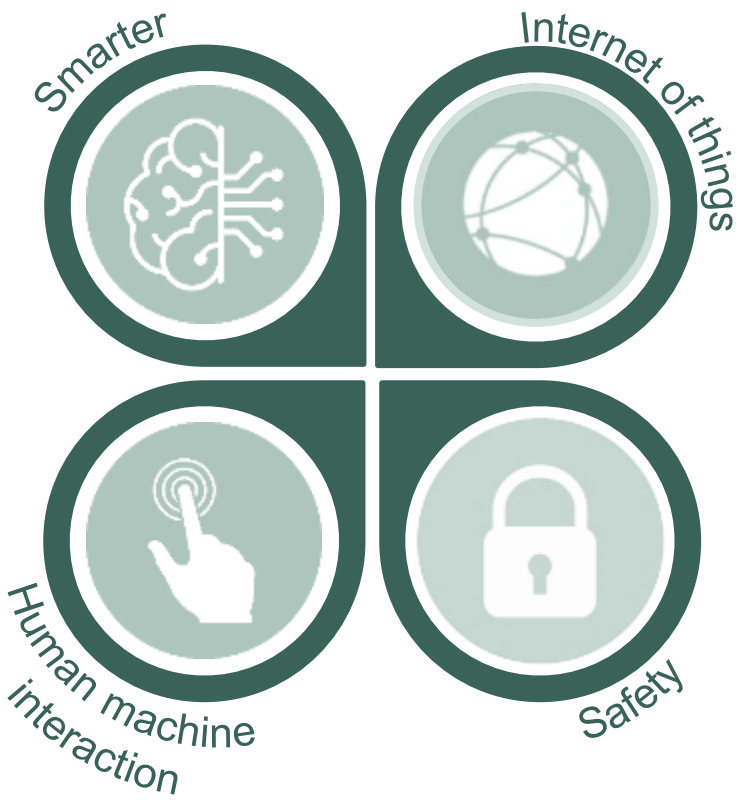
Automotive	Power	Microcontroller
		
# 1	**# 1**	**# 3**
Strategy Analytics, April 2021	Omdia, September 2021	Omdia, August 2021

For further information: Infineon Annual Report 2021

Main trends and challenges in robot applications

Robots are moving toward Industry 4.0. This brings the need for robots to be smarter and interconnected but also calls for the need for standardization.

Human-robot collaboration is one important trend in robotics. The ability to work mutually with humans, enables robots to adapt to a rapidly changing environment.



Connectivity level and the need of data security correlate, so security must be integrated into all existing and new systems, but once again calls standardization needs for diverse robots & systems to interact properly.

Safety is key when robots interact with their environment with a special focus on human safety, work safety, routing accuracy and collision avoidance

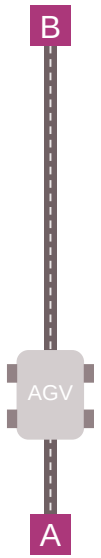
Types and deployment of mobile robots

On high level mobile robots can be categories into AGVs and AMRs

AGV

Automated Guided Vehicle

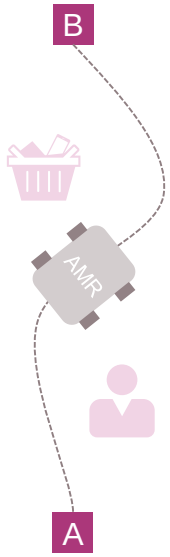
AGVs are “fixed”. They follow predefined paths using lasers, beacons, barcodes or magnetic tape.



AMR

Autonomous Mobile Robot

AMRs are not “fixed” and don’t need external paths. Autonomously mapping and navigating by using sensors



Potential use cases: warehouse & logistic, last mile delivery, robots in hotels, banks, airports etc.

Mobile robots are a fast growing market and need sophisticated system solutions for each functional block

Application requirements

Different types of mobile robots require unique and appropriate solutions

Precise, efficient & compact motor drives

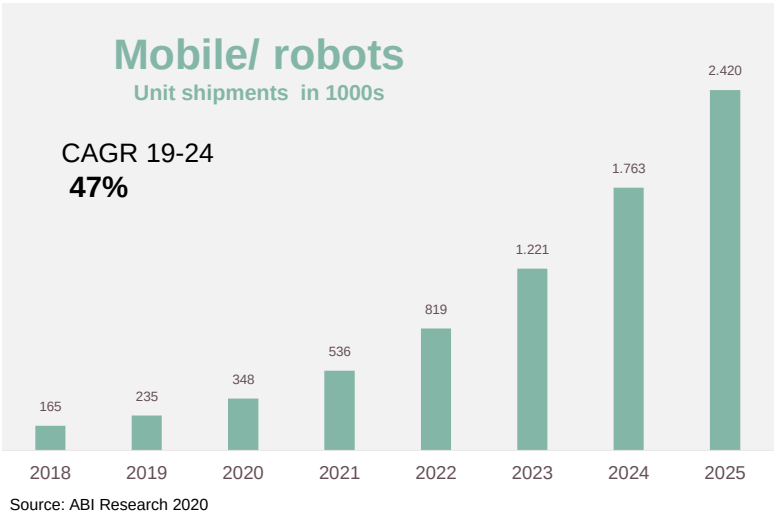
Fast charging reducing charging and idle time

Environmental sensing for navigation and safety

Connectivity enabling AI, real time monitoring and IoT

Connectivity enabling AI and IoT

Market outlook

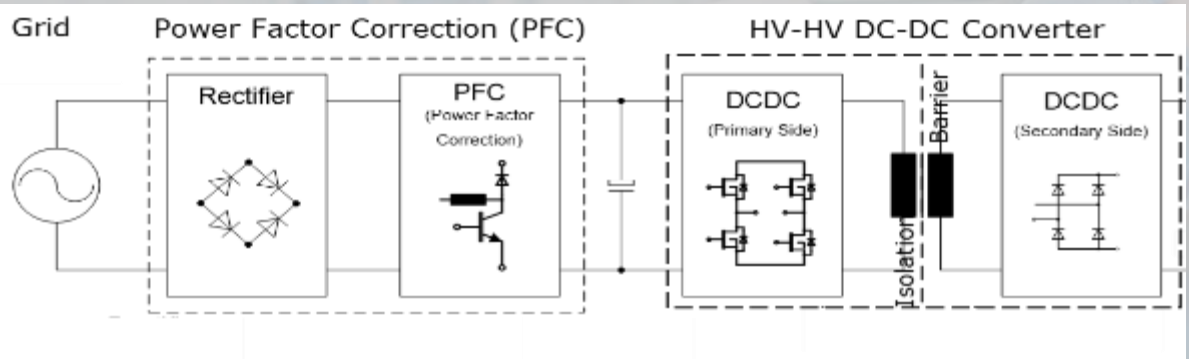


Source: ABI Research 2020

Charger & Wireless charging

Back to overview

Reduce charging cycles and increase time of operation



Power switches

- MOSFETs
- IGBT
- Gate Driver
- Isolators

AUX Power Supply

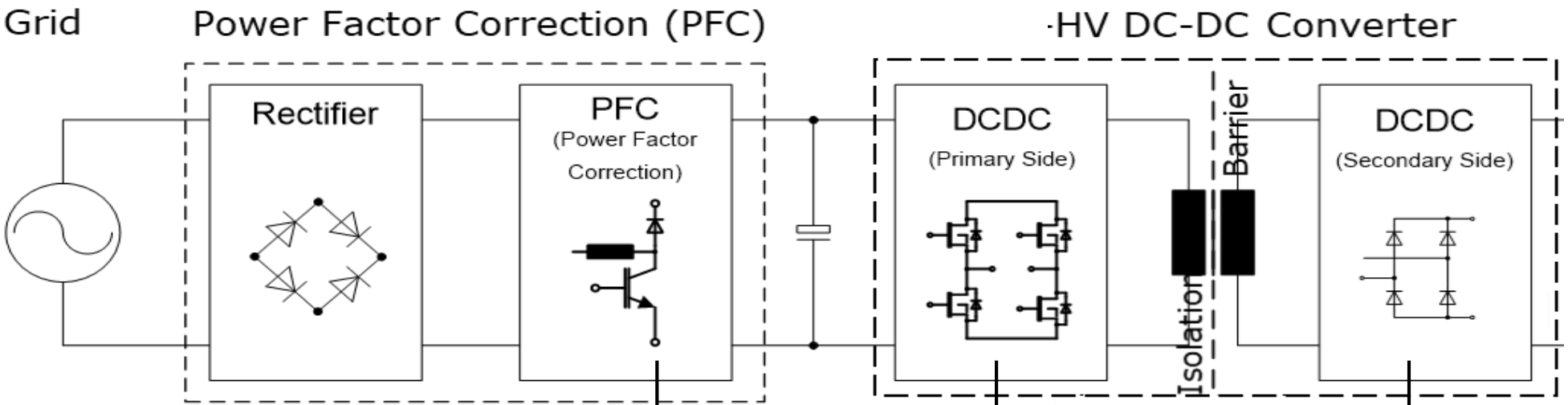
- CoolSET™

MCU

- XMC & PSoC Family

Charger Block diagram for mobile robots

PFC | **HV DCDC**



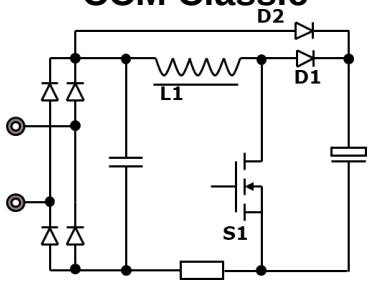
MOSFET	**CoolMOS™ CoolGaN™ CoolSiC™**
IGBT	**TRENCHSTOP™ 5**
Gate Driver	**EiceDRIVER™**
AUX Power	**CoolSET™**

MOSFET	**OptiMOS™ CoolGaN™**
Gate Driver	**EiceDRIVER™**

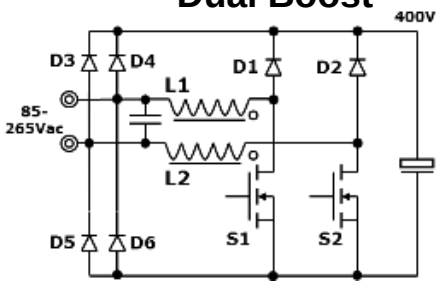
Typical topologies used in AC/DC SMPS

PFC

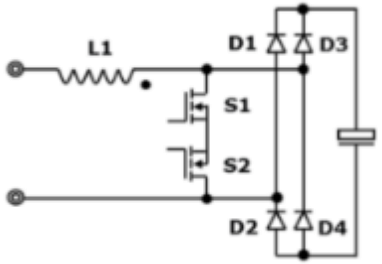
CCM Classic



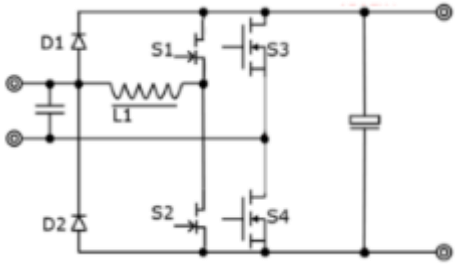
Dual Boost



H4 / H-Bridge

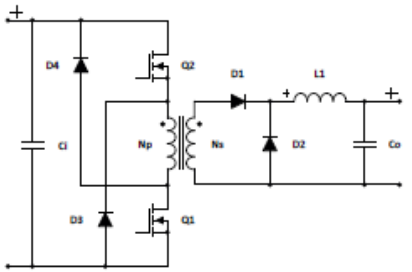


CCM Totem Pole

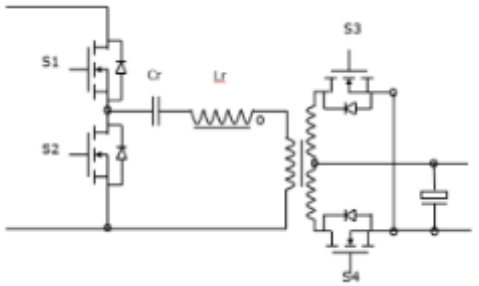


HV DCDC

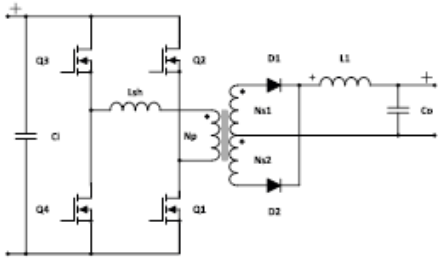
TTF



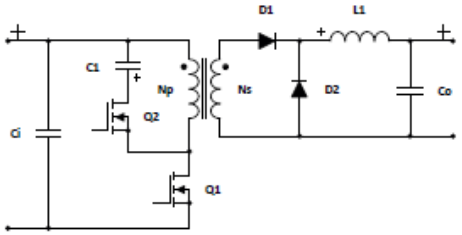
HB LLC



ZVS PSFB



Active Clamp

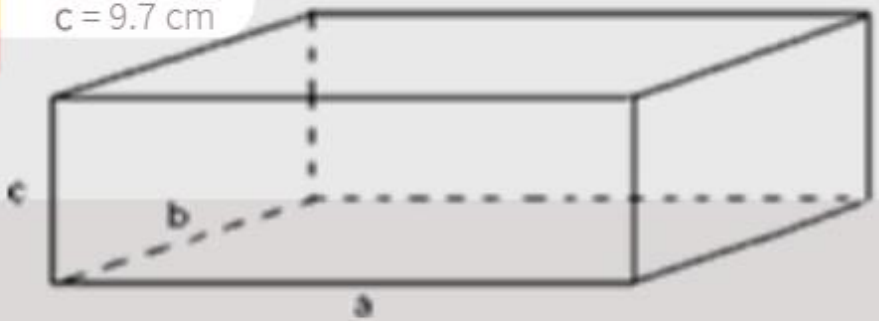


Current typical solution in industrial robots vs. Infineon high power density 1.6kW ACDC SMPS demo board

24 V/66 A SMPS for industrial robots

a = 39.5 cm
b = 20.5 cm
c = 9.7 cm

Volume =7854.5 cm³
Power density ~3.27 W/inch³



VS

90% Peak efficiency 96%

› Use of SMD power devices
› Full digital control
› Advanced planar transformer design

13 x smaller form factor

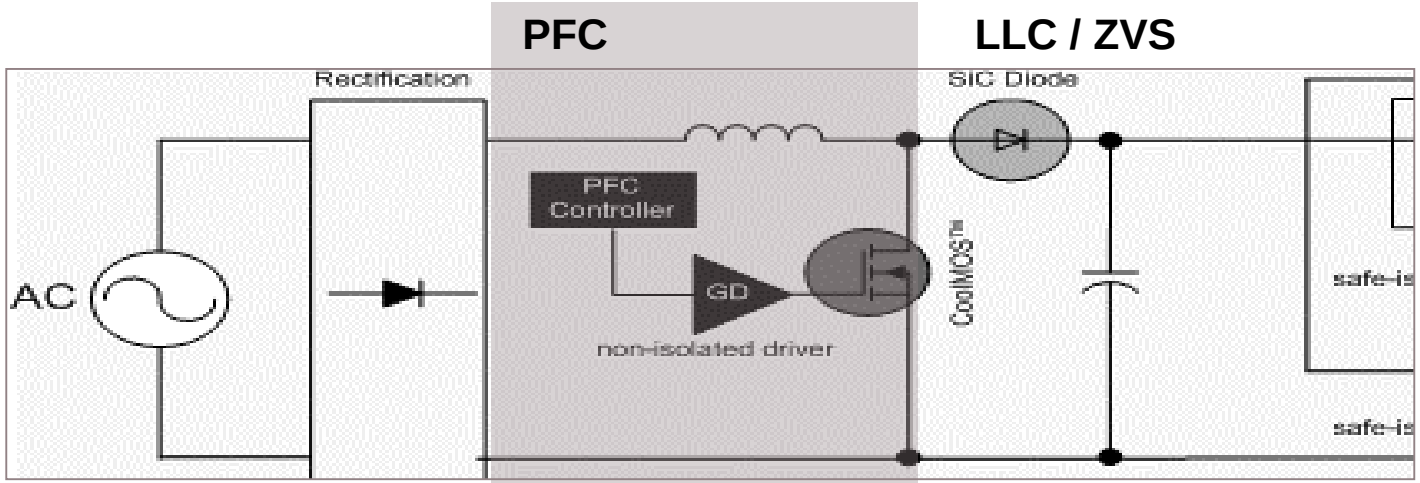
12 V/133 A IFX SMPS demo board

Same P_{out}, but double output current!

a = 19.3 cm
b = 7 cm
c = 4.4 cm

Volume =594.4 cm³
Power density ~44.2 W/inch³

CoolMOS™ C7, G7, P6 and CFD2 & CFD7 with distinctive positioning



High performance

S7

- Slow switching
- Best R_{dson}xAxPrice

C7 **G7**

- Efficiency
- Power density

CFD2 650 V **CFD7 600/650 V**

- Efficiency
- Fast body diode
- Reliability
- Ruggedness
- ZVS/LLC

C7 **G7**

- Highest efficiency
- High-end LLC

Price/ performance

P6

- Ease-of-use
- Cost

P6 **P7**

- Ease-of-use
- Cost
- LLC

Drive your CoolMOS™ to best performance with a cool EiceDRIVER™.

CoolMOS™, CoolSiC™, and CoolGaN™ in the 600 V / 650 V segment

CoolMOS™ SJ MOSFETs

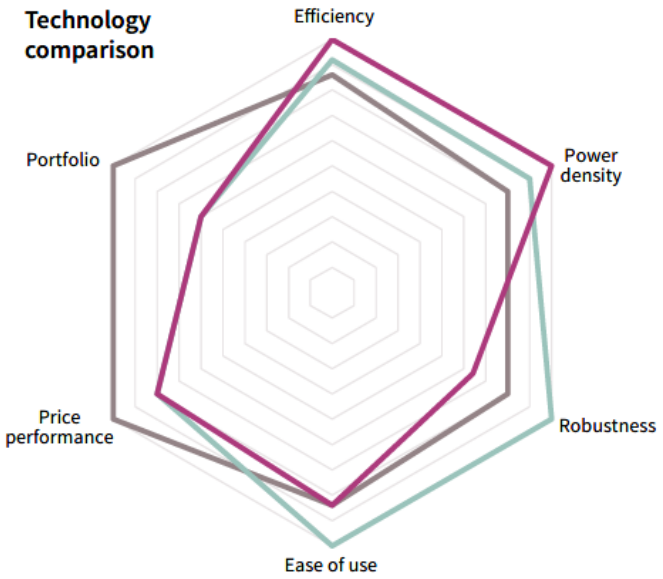
- Best price/performance for most efficiency requirements
- Largest SJ MOSFET portfolio on the market
- Mature, stable, well established

CoolSiC™ MOSFETs

- High performance combined with robustness and ease of use
- High reliability especially with high temperature and in harsh environments
- Smaller system size

CoolGaN™ HEMTs

- Highest efficiency at the highest frequency
- Smallest system size
- Enables system integration

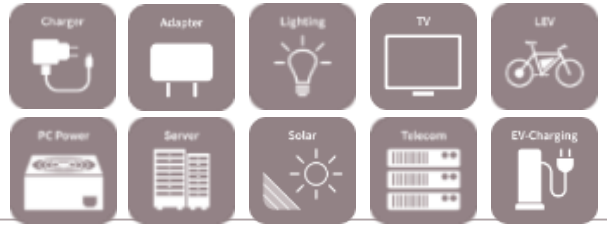


	CoolMOS™	CoolSiC™	CoolGaN™
Efficiency	★★★★☆	★★★★★	★★★★★
Frequency	★★★★☆	★★★★★	★★★★★
Power density	★★★★☆	★★★★★	★★★★★
Efficiency at maximum power density	★★★☆☆	★★★★☆	★★★★★
Robustness	★★★★☆	★★★★★	★★★☆☆
High temperature operations	★★★★☆	★★★★★	★★★★☆
Fit for bidirectional topologies	★★★☆☆	★★★★★	★★★★★
Ease-of-use	★★★★☆	★★★★★	★★★★☆
Price performance[1]	★★★★★	★★★☆☆	★★★☆☆
Portfolio granularity	★★★★★	★★★☆☆	★★★☆☆

[1] Price performance is greatly dependent on the application

600 V CoolMOS™ P7 portfolio

	$R_{DS(ON)}$ [mΩ] max.	DPAK	D²PAK	ThinPAK 8x8	TO220 FullPAK	TO220	TO220 FP NL	TO220 FP WC	TO247	TO247-4	SOT223
Industrial grade	600	IPD60R600P7			IPA60R600P7	IPP60R600P7					
	360/365	IPD60R360P7	IPB60R360P7	IPL60R365P7	IPA60R360P7	IPP60R360P7					
	280/285	IPD60R280P7	IPB60R280P7	IPL60R285P7	IPA60R280P7	IPP60R280P7					
	180/185	IPD60R180P7	IPB60R180P7	IPL60R185P7	IPA60R180P7	IPP60R180P7			IPW60R180P7	IPZA60R180P7	
	160				IPA60R160P7	IPP60R160P7					
	120/125		IPB60R120P7	IPL60R125P7	IPA60R120P7	IPP60R120P7			IPW60R120P7	IPZA60R120P7	
	99/105		IPB60R099P7	IPL60R105P7	IPA60R099P7	IPP60R099P7			IPW60R099P7	IPZA60R099P7	
	80		IPB60R080P7	IPL60R085P7	IPA60R080P7	IPP60R080P7			IPW60R080P7	IPZA60R080P7	
	60/65		IPB60R060P7	IPL60R065P7	IPA60R060P7	IPP60R060P7			IPW60R060P7	IPZA60R060P7	
	45		IPB60R045P7						IPW60R045P7	IPZA60R045P7	
	37								IPW60R037P7	IPZA60R037P7	
	24								IPW60R024P7	IPZA60R024P7	
Standard grade	600	IPD60R600P7S			IPA60R600P7S		IPAN60R600P7S	IPAW60R600P7S			IPN60R600P7S
	360	IPD60R360P7S			IPA60R360P7S		IPAN60R360P7S	IPAW60R360P7S			IPN60R360P7S
	280	IPD60R280P7S			IPA60R280P7S		IPAN60R280P7S	IPAW60R280P7S			
	180	IPD60R180P7S			IPA60R180P7S		IPAN60R180P7S	IPAW60R180P7S			



- Large $R_{DS(on)}$ and package variety
- Offering through hole and SMD packages
- Suitable for a wide variety of applications and power ranges

600 V CoolMOS™ CFD7 product portfolio
Recommended for LLC and ZVS PSFB topologies

600 V CoolMOS™ CFD7 SJ MOSFETs

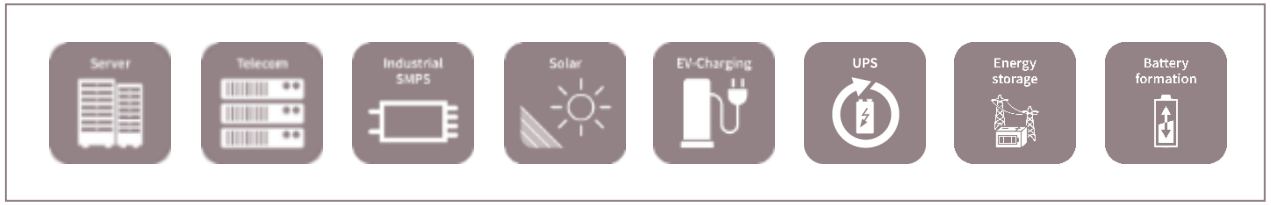
$R_{DS(on)}$ [Ω]	TO-262 D-PAK	TO-263 D²PAK	ThinPAK 8x8	TO-220 FullPAK	TO-220	TO-247	TOLL	DDPAK	QDPAK
360	IPD60R360CFD7	IPB60R360CFD7		IPA60R360CFD7	IPP60R360CFD7				
280	IPD60R280CFD7	IPB60R280CFD7		IPA60R280CFD7	IPP60R280CFD7				
210/215	IPD60R210CFD7	IPB60R210CFD7	IPL60R215CFD7	IPA60R210CFD7	IPP60R210CFD7				
170/185	IPD60R170CFD7	IPB60R170CFD7	IPL60R185CFD7	IPA60R170CFD7	IPP60R170CFD7	IPW60R170CFD7		IPDD60R170CFD7	
145/160	IPD60R145CFD7	IPB60R145CFD7	IPL60R160CFD7	IPA60R145CFD7	IPP60R145CFD7	IPW60R145CFD7	IPT60R145CFD7	IPDD60R145CFD7	
125/140		IPB60R125CFD7	IPL60R140CFD7	IPA60R125CFD7	IPP60R125CFD7	IPW60R125CFD7	IPT60R125CFD7	IPDD60R125CFD7	
105/115		IPB60R105CFD7	IPL60R115CFD7		IPP60R105CFD7	IPW60R105CFD7	IPT60R105CFD7	IPDD60R105CFD7	
90/95		IPB60R090CFD7	IPL60R095CFD7		IPP60R090CFD7	IPW60R090CFD7	IPT60R090CFD7	IPDD60R090CFD7	
70/75		IPB60R070CFD7	IPL60R075CFD7		IPP60R070CFD7	IPW60R070CFD7	IPT60R075CFD7	IPDD60R075CFD7	IPDQ60R075CFD7
55/60		IPB60R055CFD7	IPL60R060CFD7			IPW60R055CFD7	IPT60R055CFD7	IPDD60R055CFD7	IPDQ60R055CFD7
40/45		IPB60R040CFD7				IPW60R040CFD7	IPT60R045CFD7	IPDD60R045CFD7	IPDQ60R045CFD7
31/35						IPW60R031CFD7	IPT60R035CFD7		IPDQ60R035CFD7
24/26						IPW60R024CFD7			IPDQ60R025CFD7
18/20						IPW60R018CFD7			IPDQ60R020CFD7
15									IPDQ60R015CFD7

Q2 CY 2021 | Q4 CY 2021

650 V CoolSiC™ MOSFET portfolio

$R_{DS(on),max}$ [mΩ] **18 V**	$R_{DS(on),typ}$ [mΩ] **18 V**	TO-247-4 (asymmetric leads)	TO-247-3
34	27	IMZA65R027M1H	IMW65R027M1H
64	48	IMZA65R048M1H	IMW65R048M1H
94	72	IMZA65R072M1H	IMW65R072M1H
142	107	IMZA65R107M1H	IMW65R107M1H

Target applications



Gate-driver IC recommendation for 650 V CoolSiCTM

Example use-case	Power class	Recommended 650 V CoolSiC™ Rdson class	Gate-driver IC recommendation
CCM tote pole PFC**	**3.9 kW**	IMx65R0**27**M1H (32 A*)	**2EDF9275F** or 2x **1EDB9275F**
	3.3 kW	IMx65R0**48**M1H (27 A*)	
	2.8 kW	IMx65R0**72**M1H (23 A*)	
	2.3 kW	IMx65R**107**M1H (19 A*)	
LLC DC-DC***	-	any	**2EDS9265H**

* RMS peak current at worst nominal case (176 V_{IN} RMS, 97.4% efficiency at full-load); for the real peak value a 30% ripple has to be considered on top

*** functional isolation required

*** reinforced isolation required

UVLO protects the CoolSiC™ in case the supply drops from the nominal value (18 V V_{GS}) to a lower value (12.6 V V_{GS}).

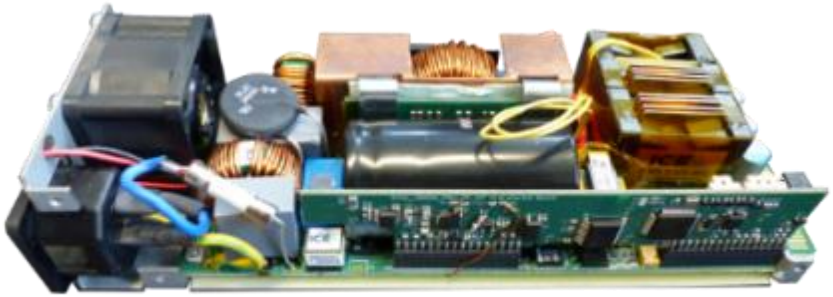
A proper thermal design is needed in addition.

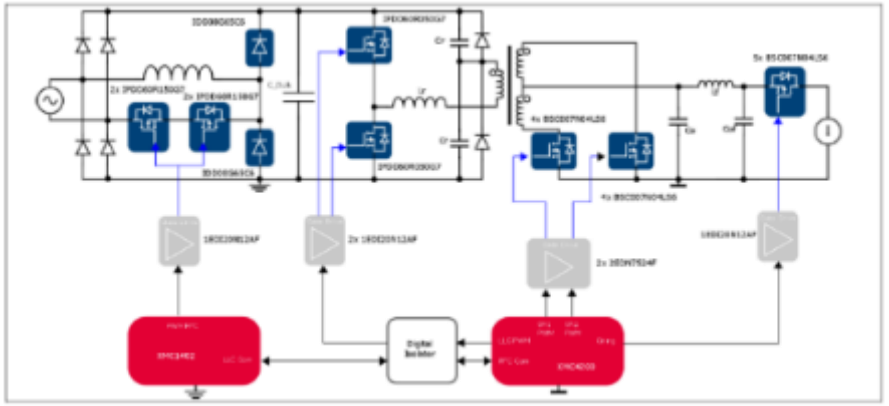
2EDx9275x, 1EDB9275F UVLO rating

Parameter	Symbol	Values			Unit	Note or Test Condition
		Min.	Typ.	Max.		
Undervoltage Lockout (UVLO) turn-on threshold V_{DD4}, V_{DDB}	UVLO_CM$_{on}$	13.0	13.7	14.2	V	–
Undervoltage Lockout (UVLO) turn-off threshold V_{DD4}, V_{DDB}	UVLO_CM$_{off}$	–	12.6	–	V	–
UVLO threshold hysteresis V_{DD4}, V_{DDB}	UVLO_CM$_{hys}$	0.4	0.8	1.2	V	–

EVAL_1K6W_PSU_G7_DD:
Infineon demo board suitable for industrial robotics SMPS applications

EVAL_1K6W_PSU_G7_DD





Technical specifications

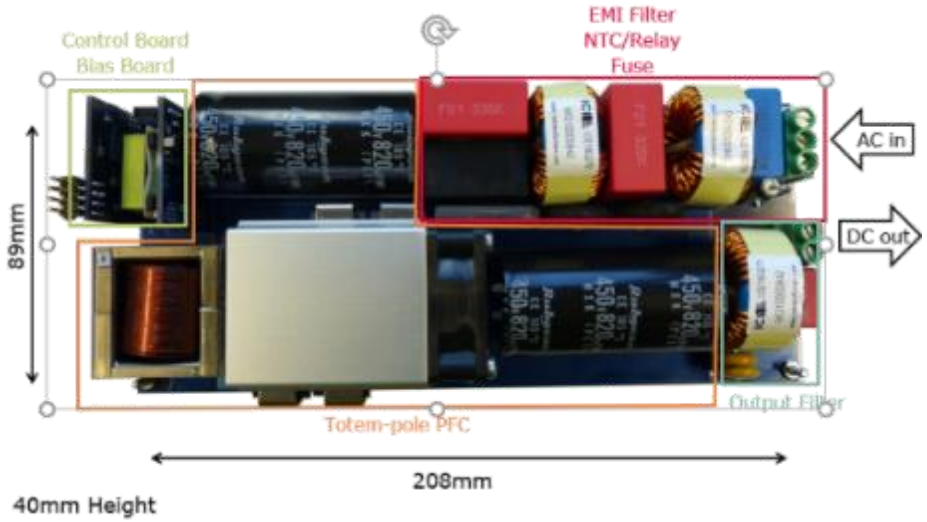
Key requirements	Value
Input voltage	176-265 Vac
Output voltage	12 V
Output current	133 A
Output power	1600 W
Peak Efficiency @ 50%load	≥96%
Power Density	~55 W/in³

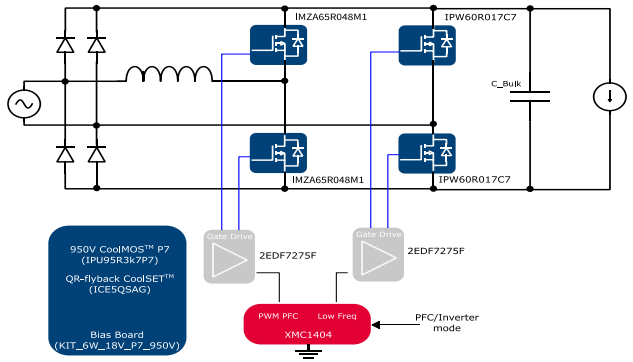
Key components

Infineon components	› IPDD60R050G7 › IPDD60R150G7 › IDDD08G65C6 › BSC007N04LS6 › 1EDI20N12AF › 2EDN7524F › ICE2QR2280GQR › XMC1402 (PFC) & XMC4200 (LLC) MCUs

EVAL_3K3W_TP_PFC_SIC:
Infineon demo board suitable for industrial robotics bi-directional PFC

EVAL_3K3W_TP_PFC_SIC





Technical specifications

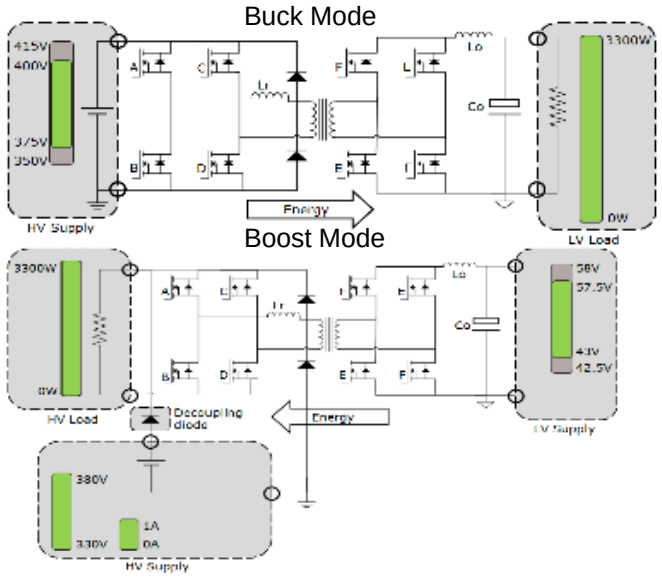
Key requirements	Value
Input voltage	176 V_{AC} - 265 V_{AC}
Output voltage	300 V_{DC} – 450 V_{DC}
Max. Power	3300 W
Peak efficiency (AC-DC & DC-AC @ 50% load)	≥98.8%
Power Density	~72 W/inch³

Key components

Infineon Components	› 2x IMZA65R048M1 CoolSiC™ › 2x IPW60R17C7 › 2x 2EDF7275F › XMC1404 microcontroller › 6 W 18 V bias board (KIT_6W_18V_P7_950V) with › IPU95R3k7P7 (flyback switch 950 V) › ICE5QSAG (QR flyback controller)

EVAL_3k3W_BIDI_PSFB:
Infineon demo board suitable for bi-directional isolated DC/DC conversion

EVAL_3k3W_BIDI_PSFB



Technical specifications

Key requirements	Value
Input voltage	320-420 Vdc
Output voltage	54.5 V_{DC_NOM} (43-59Vdc)
Output current	60.5 A
Output power	3300 W
Peak Efficiency (Buck Mode @ 50%load)	≥98%
Peak Efficiency (Boost Mode @ 50%load)	≥97.5%
Power density	~96 W/inch³

Key components

Infineon components	› 8 x IPL60R075CFD7 › 2 x 2EDS8487H › 2 x 2EDF8487F › XMC4200-F64k256AB › 16 x BSC093N15NS5 › IDH08G65C6 › ICE5QSAG › IPU80R4K5P7

It is not just about charging phones - wireless charging will become an essential part for charging various devices in the future

RX shipments - 2019: 516M 2023: 1.333M (CAGR of 27%)
TX shipments - 2019: 230M 2023: 671M (CAGR 31%)

Smartphones & wearables are largest segments (commodity, integrated Rx)

WPC Qi standard is expanding to **higher power levels enabling new apps** (>45W)

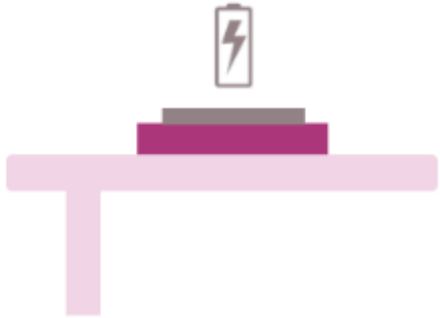
Increasing wireless charging installations (home, **public infrastructure**, restaurants)

Out-of-band communication based on bluetooth introduced in higher power wireless charging

Authentication will become mandatory in WPC Qi 1.3 Spec

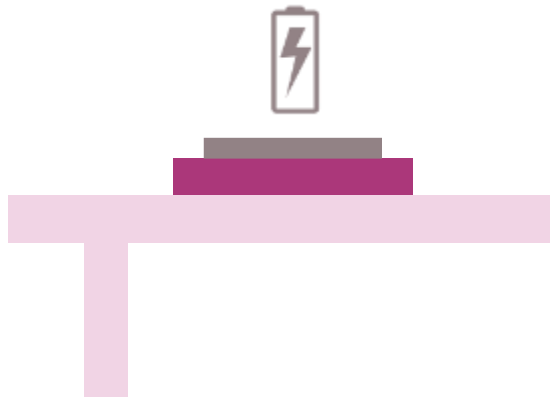
Inductive is the dominating standard – resonant is expected to be used in selected niche markets but will just take a smaller portion of the market

Main standards in the market

Tightly coupled	Loosely coupled
Inductive	**Resonant**
Low frequency 110 - 205 kHz	High frequency 6.78 MHz
	
WIRELESS POWER CONSORTIUM	AirFuel™ Alliance

Various standards available in the market – Infineon focuses on inductive and resonant technologies

Tightly coupled	Loosely coupled	Uncoupled
Inductive	**Resonant**	**RF, ultrasound, infrared etc.**
Low frequency 110 - 205 kHz	High frequency 6.78 MHz	



WIRELESS POWER CONSORTIUM

AirFuel™ Alliance

energous

OSSIA REAL WIRELESS POWER

humavox Wireless Power Technologies

Infineon focus area

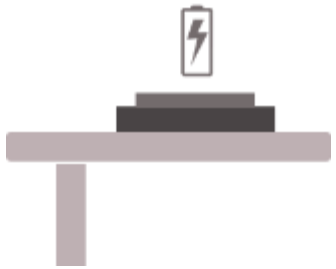
Inductive vs. resonant: efficiency vs. greater user experience

Tightly coupled

Inductive
110-205kHz

Inductive

- Low frequency 110 - 205 kHz
- In-band communication
- Exact positioning of device
- Wire coils with heavier ferrite shields
- Single device charging
- Efficiency >80% → approaching wired charging
- Qi standard expanding to higher power (up to 2500 W)
- Leading technology in the market



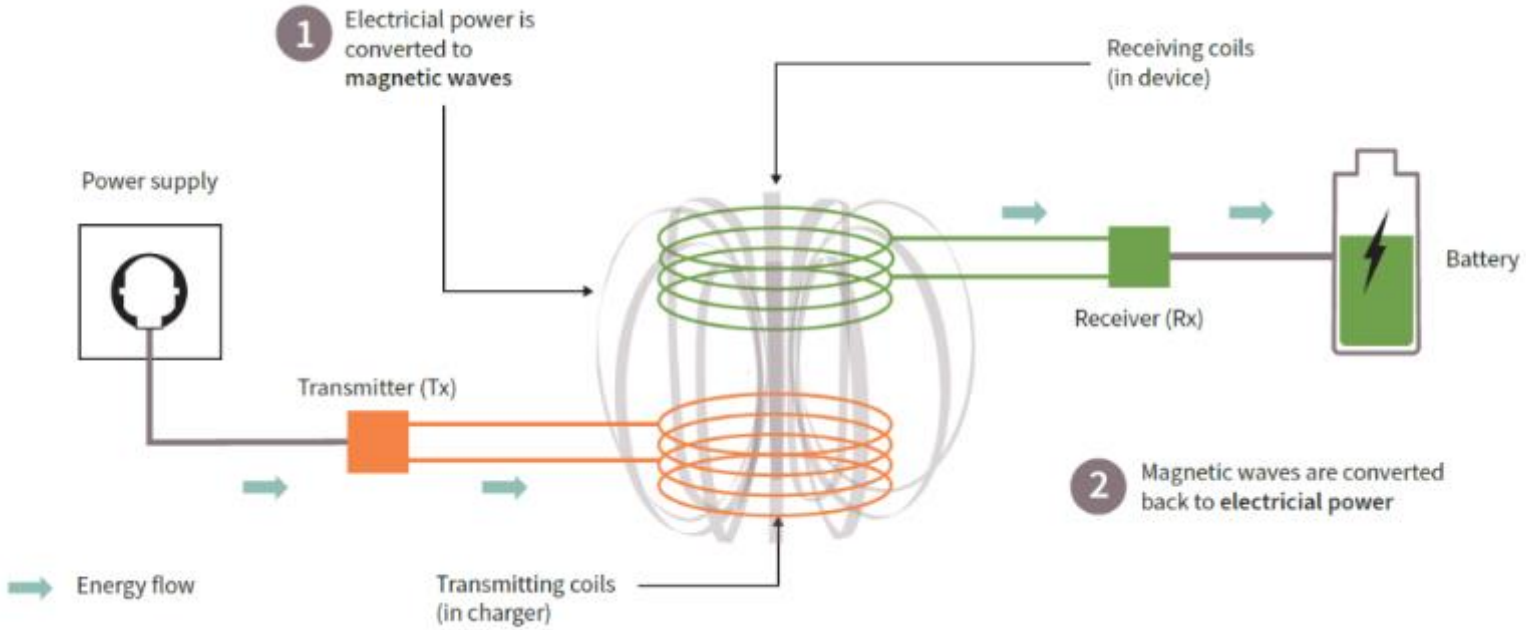
Loosely coupled

Resonant
6.78 MHz

Resonant

- High frequency - 6.78 MHz
- Bluetooth out-of-band or in-band communication
- Free positioning (up to >30 mm vertical freedom)
- PCB coils without ferrite shields
- Single and multiple device charging
- Efficiency ~70% → tradeoff of some efficiency for flexibility
- Standard supports power levels up to 50 W
- Perfectly fits to unique form factors and applications that require spatial flexibility

Wireless charging is not a trivial endeavor: Safety and user experience are key



Safe and efficient wireless charging

- Requires a deep level of system knowledge and expertise
- Must understand antennas and interaction with surrounding structures
- Success requires precise control of power delivery

If done incorrectly, it can impact the user experience

- Compatibility issues
- Safety issues
- Thermal issues during charging
- Reduced efficiency and increased charging time
- Device and battery damage

Key benefits why to choose Infineon for consumer & industrial wireless charging designs

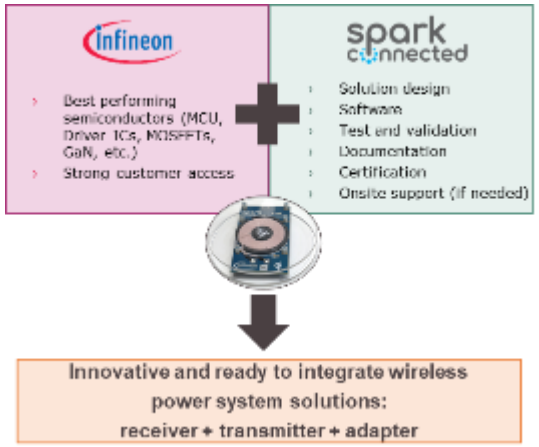
Addressing the leading standards – **inductive & resonant**

Tightly coupled	Loosely coupled
Inductive	**Resonant**
Low frequency 110 - 205 kHz	High frequency 6.78 MHz
WIRELESS POWER CONSORTIUM	AirFuel Alliance

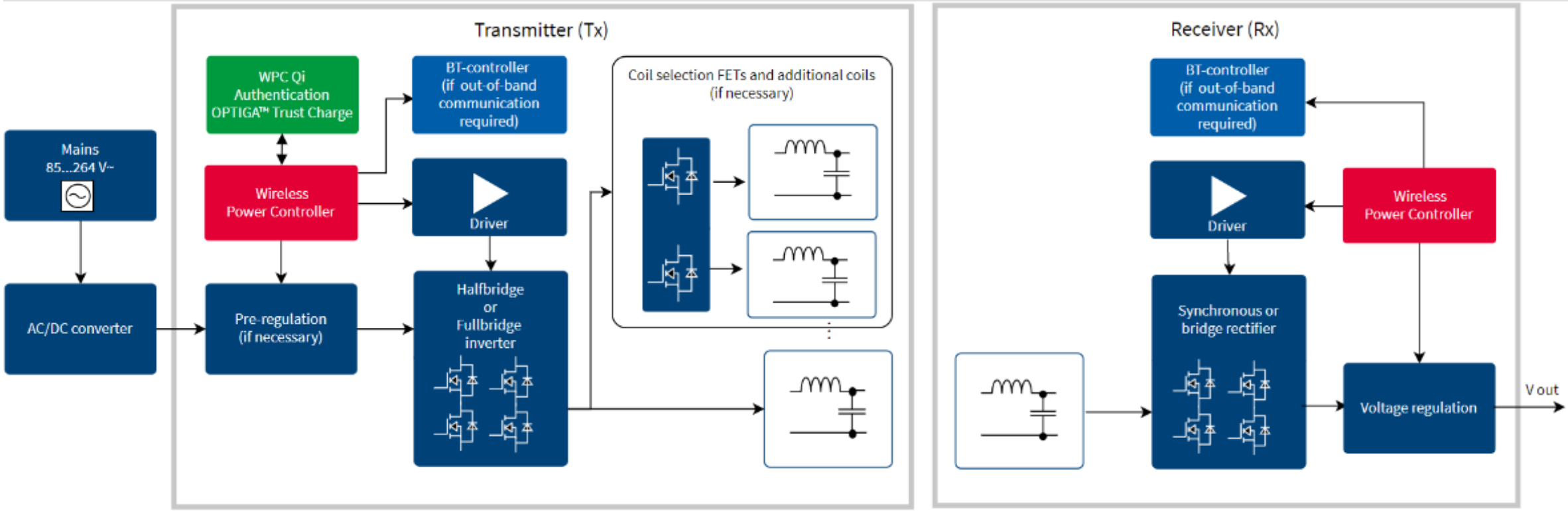
Offering the **right components** for efficient wireless charging experience

MOSFETs, driver ICs, Small Signal, MCU, voltage regulators, GaN, LDOs, authentication, USB Type-C port controller or a BLE module

Providing innovative, smart and high performance **system solutions together with our partner**



Infineon a one-stop-shop with excellent devices to ensure safe and efficient wireless power transfer – example inductive TX and RX



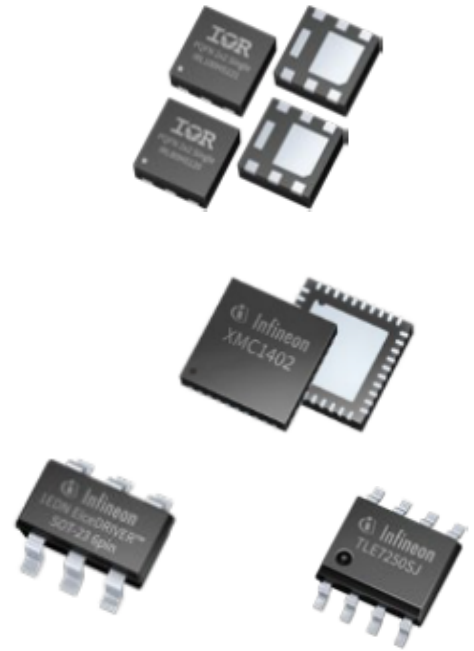
Key enabling products

MOSFETs	Driver ICs	Small signal & LDOs	BT connectivity
GaN	Microcontroller	USB-C Controller	Authentication

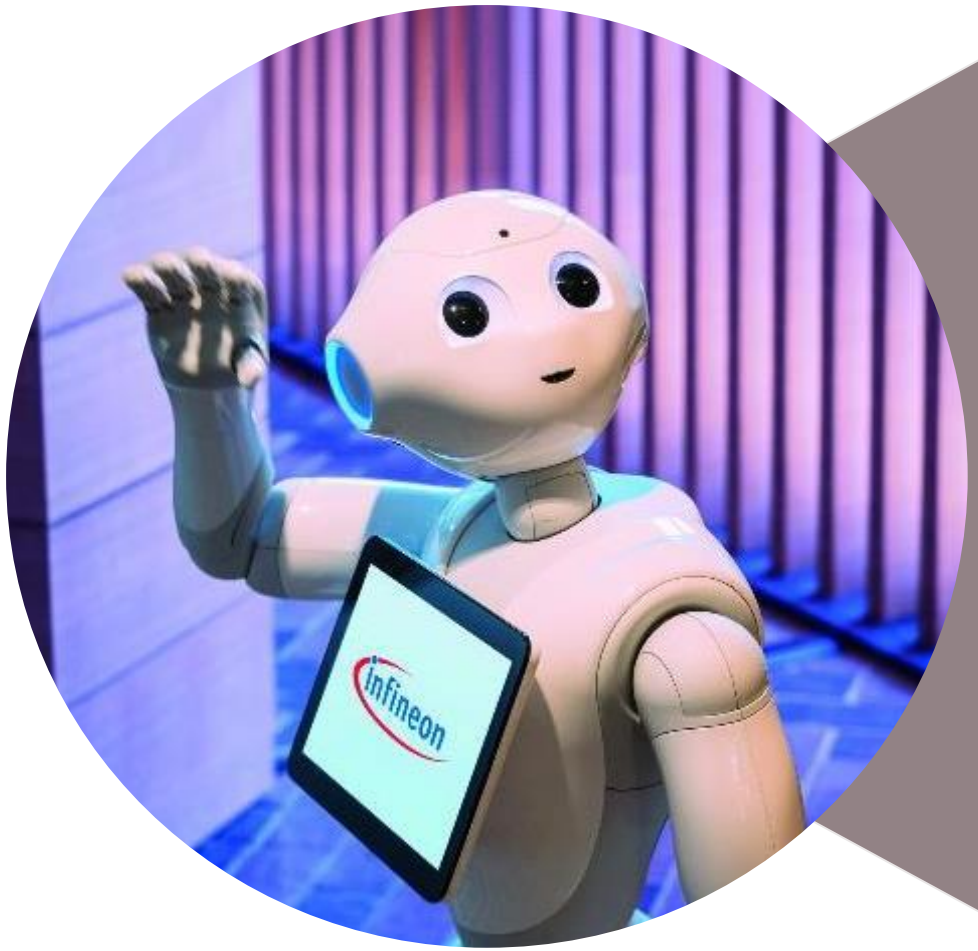
Key enabling products for consumer & industrial wireless charging

Key enabling products

- Low and medium voltage **power MOSFETs** – OptiMOS™ and StrongIRFET™
- **Gate driver ICs** – EiceDRIVER™
- **32-bit microcontrollers – XMC™**
- P-channel and N-channel small signal power MOSFETs
- **High-voltage power MOSFETs** – CoolMOS™ Superjunction MOSFETs
- **PWM/flyback controllers and integrated power stage ICs** – CoolSET™
- **Gallium nitride (GaN)** – CoolGaN™ e-mode HEMTs
- Voltage and buck regulators for component and bridge supply
- **Authentication** – OPTIGA™ Trust Charge
- **Reverse conducting IGBTs** – 650 V TRENCHSTOP™ 5
- **New products from Cypress**: USB Type-C Port Controller or a BLE Module



Further Material – Charger



Portfolio and further information can be found here:

- Link ➔ Charger Solutions
- Link ➔ Wireless Charging Solutions
- Link ➔ CoolMOS™ MOSFETs
- Link ➔ EiceDRIVER™ Solutions

Learn more on our webpage

Part of your life. Part of tomorrow.