High Performance Solution for EV Charging

Agenda

1. Driving Force of EV Charging
2. DC EV Charging Solution
3. OBC and DC/DC Solution for EV
4. Summary

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Why is EV blooming?

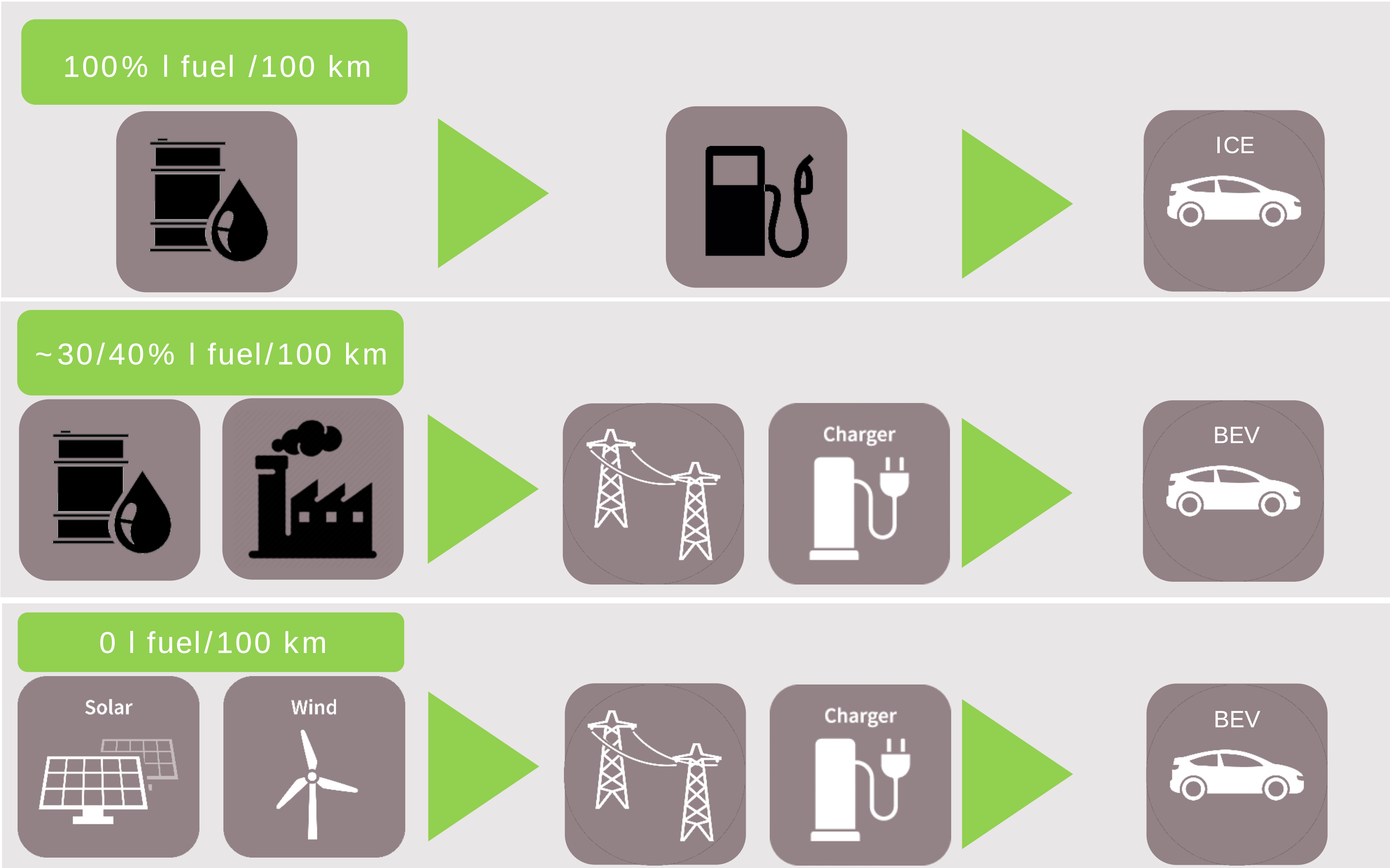
Government regulations on CO_2 emissions

High pollution index in cities

Continuous decrease in battery costs

E-mobility is a fast growing market

Achieving zero-emission with e-mobility



AC and DC Charging for EV

EV charging

DC-charger

AC- charger

Agenda

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Shorten charging times by fast DC EV charging

DC charging System	20 kW** (2 subunit of 10 kW)	50 kW (3 subunits of 20 kW each)	150 kW (5 subunits of 30 kW each)	350 kW (6 subunits of 60 kW each)
Charging time*	120 min	48 min	16 min	7 min

*) Charging time for 200km **) incl. DC Wall-Box

Subunit: A power electronic arrangement build from both active and passive components to convert AC input to dedicated DC output. Often referred to as "module".

Requirements and trends at a glance

Power range

- Main stream in China is each subunit with 15kW, by stacking up to 120 kW
- 30 kW subunit design is ongoing, by stacking up to 240 kW
- Increase power is a trend, higher power for subunit is required

Topology

	PFC		DC-DC	
Topology	T type Vienna	I type Vienna	Stacked Full Bridge LLC	Single Full Bridge LLC
Component	1200 V fast diode/SiC diode 650/650 V CoolMOS™/IGBT	650 V fast diode / SiC diode 600V/650 V CoolMOS™/IGBT	600 V CoolMOS™	1200 V SiC MOSET
Switching frequency	30-50 kHz	30-50 kHz	100-200 kHz	100-200 kHz

Output voltage

- Wide output voltage range from 200 V to 1000 V with constant power
- The maximum output current is based on lowest output voltage
- 200 V to 500 V output voltage for subunits

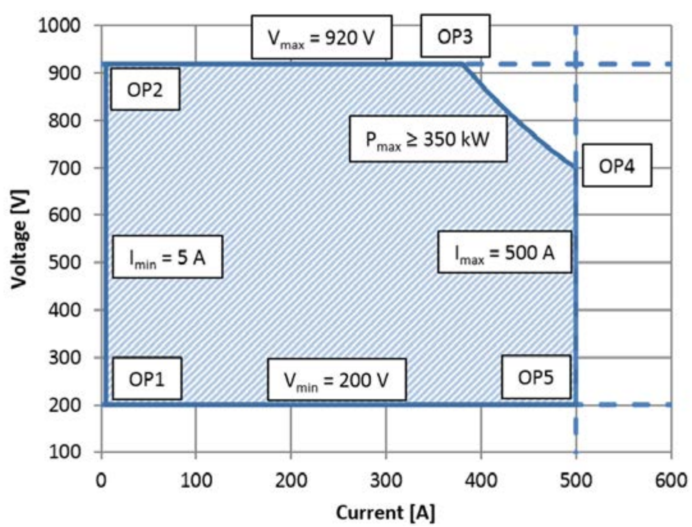
Cost

- Economic solution with CoolMOS™ and IGBT
- Vienna Rectifier for PFC (T-Type ⇨ I-Type)
- SiC MOSFET is preferred for compact and efficient design

Based on estimation from IFX experts

Wide variation of DC output voltage

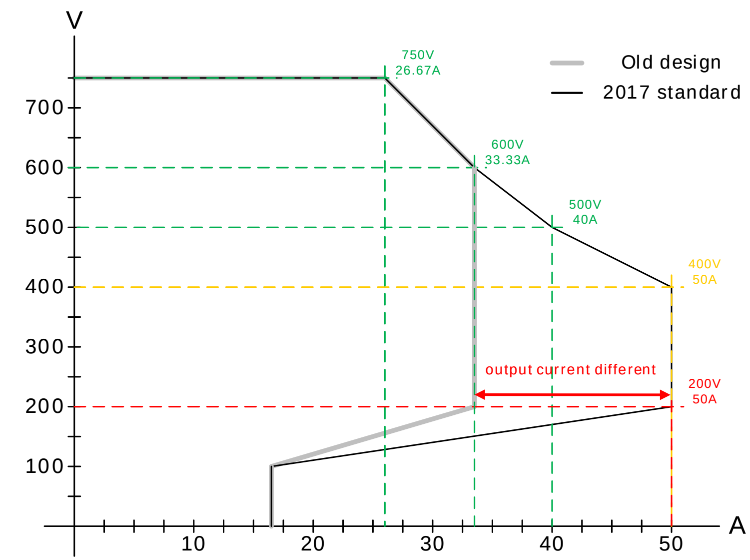
200 V to 920 V for up to 350kW DC charger acc. CCS



Source: CharIn

- The standard requires constant output power at 700 V
- Output Voltage range from 200V to 920V
- Output current varies from 5A to 500A

20 kW DC charger acc. new China State Grid standard



- Each power module in each charger is limited to a maximum of 20 kW
- Trend is going to 30 kW
- Aim to use only one type of charging subunit to fulfil both EV private car and bus charging needs
- The standard requires the constant output power at 400 V
- No change in existing design of PFC stage but in DC-DC stage to fulfill the new range

Leading semiconductor provider in DC EV charging

Comprehensive offering

We are benchmark in all products of our broad portfolio ranging from power and control to sense and security

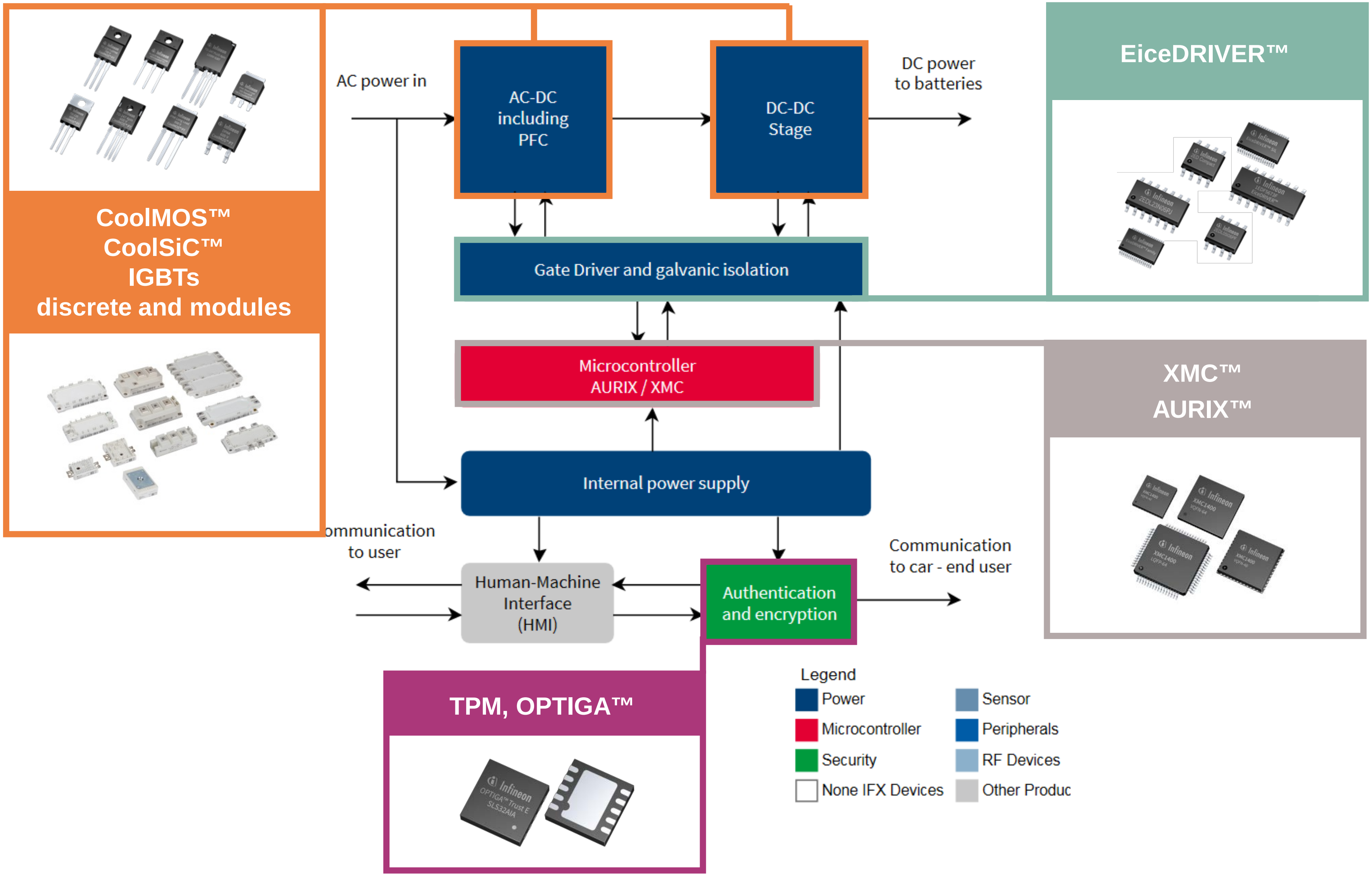
System expertise

With our unmatched system understanding we empower a broad range of applications related to DC EV charging:
from telecom and industrial power supply to e-mobility and embedded security

Unmatched scale

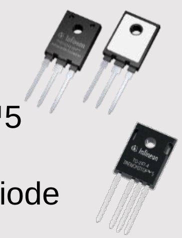
Biggest power player with strongest manufacturing capabilities

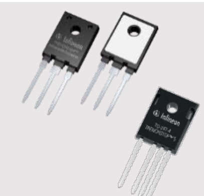
Key portfolio for DC EV charging designs

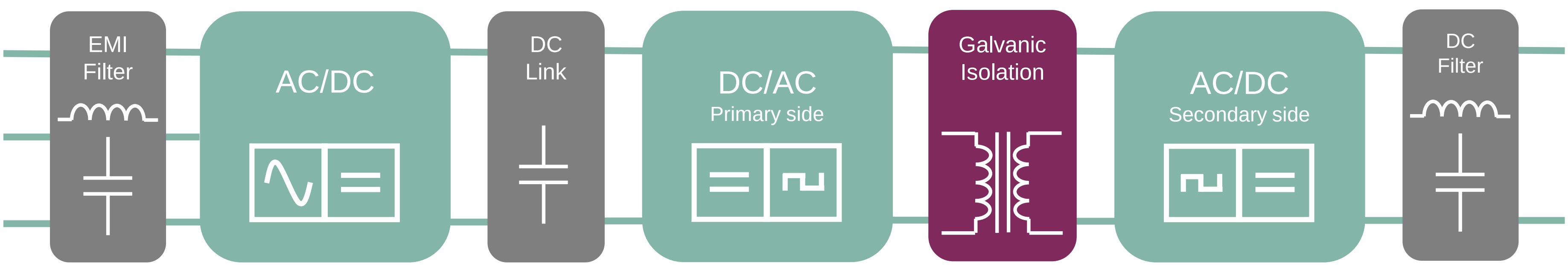


Typical topologies for chargers from 30 kW to 150 kW using discrete devices

Stacking of subunits 3 phase AC input Galvanic isolation within the subunit Power of subunit 15-30 kW	Vienna Rectifier for PFC Stage	600 VCoolMOS™ P7 650 V IGBT TRENCHSTOP™5 1200 V CoolSiC™ Schottky Diode
	Resonant converter for DC/DC Stage	600 VCoolMOS™ CFD7 1200 V CoolSiC™ MOSFET 650 V / 1200 V CoolSiC™ Schottky Diode







Trends and key drivers for DC EV charging

Higher output power

Reduction of cost per watt

Higher efficiency

Higher power density

CoolMOS™ 7 for EV charging application in a nutshell

Best-fit performance for target applications

- **Best fit** efficiency for **EV charging applications** in terms of
  - Significant reduction of switching losses (E_{oss})
  - Improved gate charge (Q_g)
  - Lower $R_{DS(on)}$ per package (TO-220, ThinPAK, TO-247)
- Enabling high **power density and efficiency designs**

Adequate ease-of-use

- **600 V CoolMOS™ P7** offers
  - Outstanding commutation ruggedness
  - Smooth switching waveforms
- **600 V CoolMOS™ CFD7** offers
  - Best-in-class body diode robustness
  - Early channel shut down allows increase of $RG_{on, ext.}$ without negative impact on efficiency

Price/performance ratio and quality

Best-in-class price/performance ratio

- Attractive price position for high performance technology
- Highly attractive compared to previous Infineon technologies

Granular portfolio

- $R_{DS(on)}$ range from 70 down to 18 mΩ in the common TO-247 package
- Enabling higher output power

High Infineon quality

CoolMOSTM 7 to address EV charging market

600 V CoolMOS™ P7 | **600 V CoolMOS™ CSFD/CFD7**

Suitable for
PFC and LLC topologies

Recommended for usage in
PFC stage in EV Charging

Suitable for
LLC and PS FB ZVS topologies

Recommended for usage in
DC/DC stage in EV Charging

Technology corner stones

- **Best balanced technology** of all CoolMOS™ families
- Integrated Zener diode
- **Perfect combination** of
  - Highest efficiency and improved thermals
  - Excellent ease-of-use & commutation ruggedness
  - Competitive price and
  - Outstanding portfolio granularity

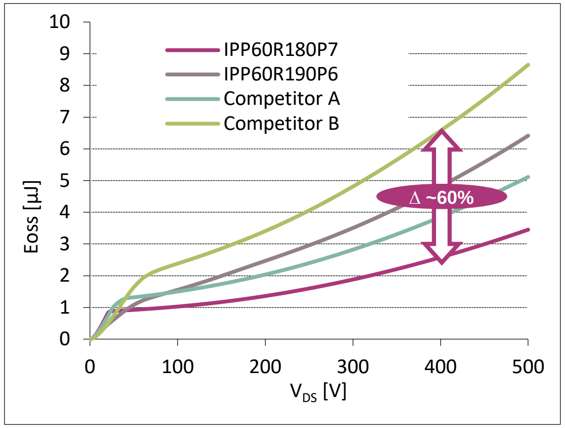
+ 

- **Ultra fast body diode** and **best-in-class Q_{rr} level** of all CoolMOS™ families
- Highest **reliability and robustness**
- Highest efficiency within CoolMOS™ fast body diode series
- Enabling **highest power density levels** thanks to best-in-class $R_{DS(on)}$ in THD and SMD packages
- IPW60R037CSFD as optimized replacement for IPW65R041CFD

+ 

600 V CoolMOSTM P7
Technological highlights

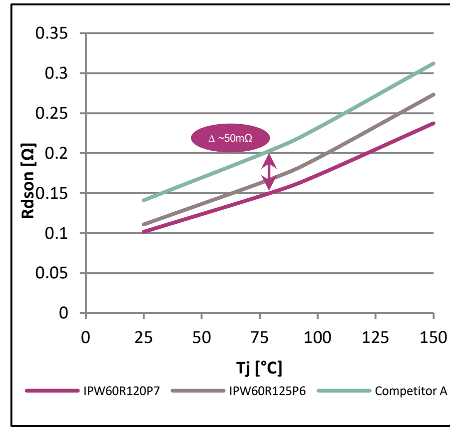
Best-in-class E_{oss}



Customer benefits

- Up to 60 % lower Eoss compared to main competition
- Reduced switching losses leading to higher light load efficiency

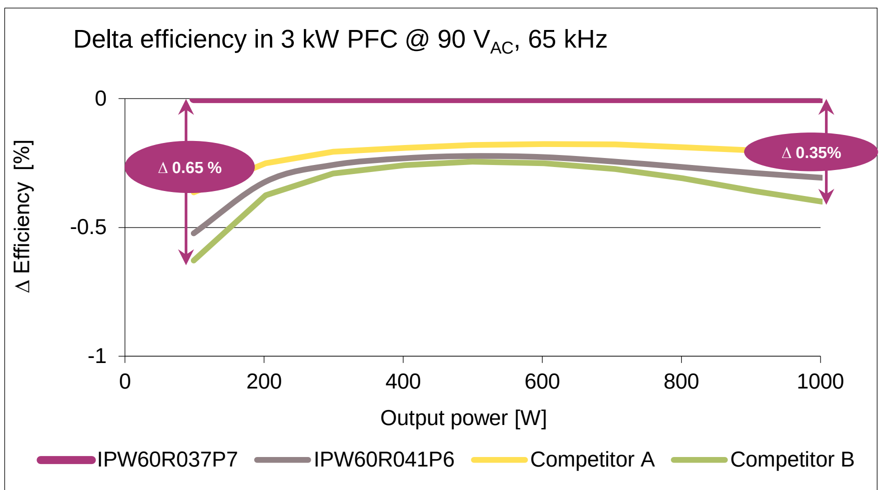
Best-in-class $R_{DS(on)}$ dependency over T_j

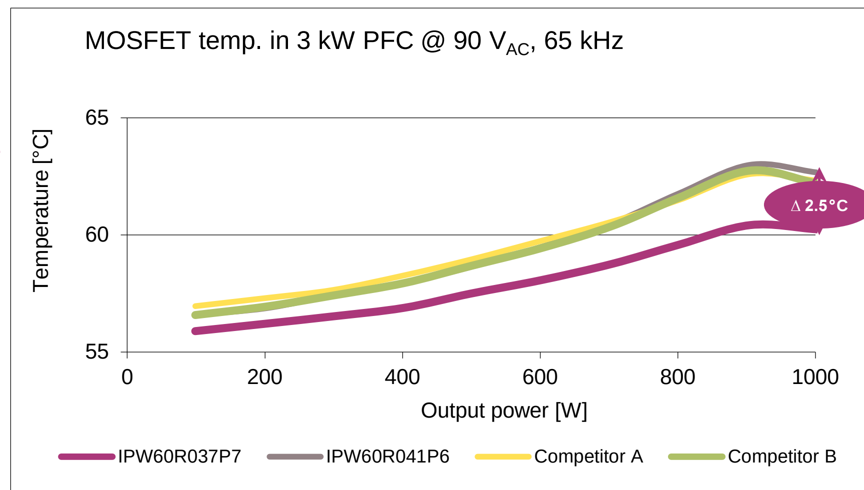


CoolMOS™ P7

- Lower $R_{DS(on)}$ increase with increasing junction temp.
- Reduced conduction losses leading to improved full load efficiency

Improved efficiency and thermals compared to main competition





600 V CoolMOSTM P7
Product portfolio

600 V CoolMOS^{TM} P7 SJ MOSFETs

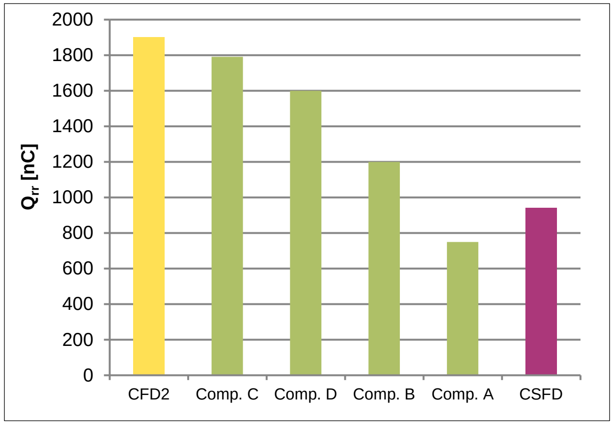
	$R_{DS(on)}$ [Ω]	DPAK	D²PAK	ThinPAK 8x8	TO220 FullPAK	TO220	TO220 FP NL	TO220 FP WC	TO247	TO247-4	SOT223
Ind. Grade	600	IPD60R600P7			IPA60R600P7	IPP60R600P7					
	360/365	IPD60R360P7	IPB60R360P7	IPL60R365P7	IPA60R360P7	IPP60R360P7					
	280/285	IPD60R280P7	IPB60R280P7	IPL60R285P7	IPA60R280P7	IPP60R280P7					
	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	
Std. Grade	600	IPD60R600P7S			IPA60R600P7S		IPAN60R600P7S	IPAW60R600P7S			IPN60R600P7S
	360	IPD60R360P7S			IPA60R360P7S		IPAN60R360P7S	IPAW60R360P7S			IPN60R360P7S
	280	IPD60R280P7S			IPA60R280P7S		IPAN60R280P7S	IPAW60R280P7S			
	180	IPD60R180P7S			IPA60R180P7S			IPAW60R180P7S			

ES by spring 2018
Launch by beginning of 2019

HBM Class 2C: 120 - 600mΩ

600 V CoolMOSTM CFD7 Technological highlights

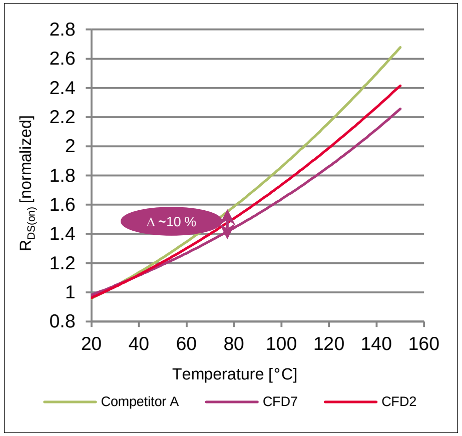
Best-in-Class Q_{rr}



CoolMOS™ CSFD secures an outstanding Q_{rr} level, even at a lower $R_{DS(on)}$

IPW60R037CSFD offers better Q_{rr} level than most 40 mΩ range competitors

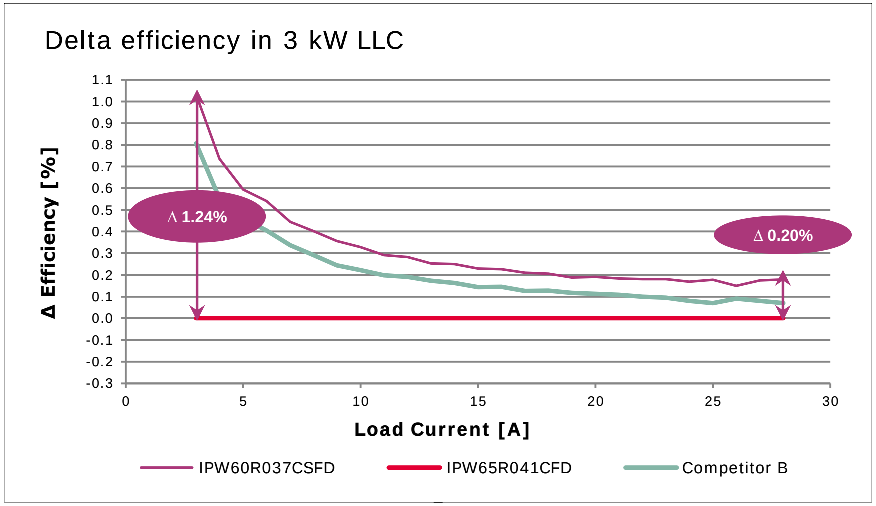
Best-in-Class $R_{DS(on)}$ dependency over T_j



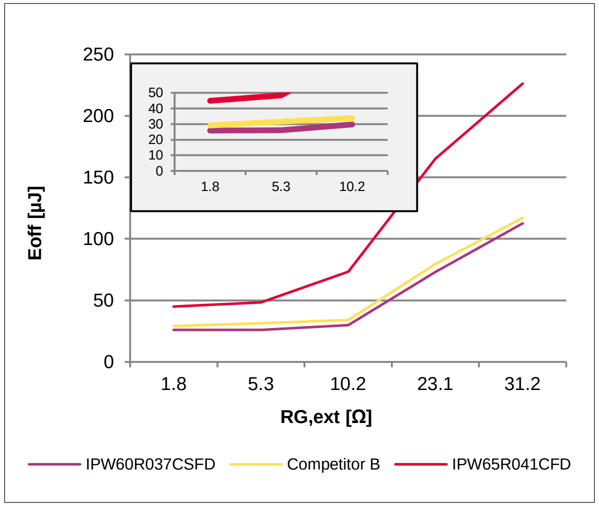
CoolMOS™ CFD7

- lower $R_{DS(on)}$ increase with increasing junction temp.
- Reduced conduction losses leading to improved full load efficiency

Improved Efficiency over competition



Early channel shut down to improve oszillation tendency



CoolMOS™ CFD7

- Has nearly no increase of the E_{off} losses until an external gate resistor of up to 10 Ω
- Shows a much more flat E_{off} increase at higher RG_{ext} than CFD2

600 V CoolMOSTM CFD7
Product portfolio

600 V CoolMOS™ CFD7 SJ MOSFETs

$R_{DS(on)}$ [Ω]	TO-263 D²PAK	TO-252 D-PAK	ThinPAK 8x8	TO-220	TO-220 FullPAK	TO-247
360	IPB60R360CFD7	IPD60R360CFD7		IPP60R360CFD7	IPA60R360CFD7	
280	IPB60R280CFD7	IPD60R280CFD7		IPP60R280CFD7	IPA60R280CFD7	
210/225	IPB60R210CFD7	IPD60R210CFD7	IPL60R225CFD7	IPP60R210CFD7	IPA60R210CFD7	
170/185	IPB60R170CFD7	IPD60R170CFD7	IPL60R185CFD7	IPP60R170CFD7	IPA60R170CFD7	IPW60R170CFD7
145/160	IPB60R145CFD7	IPD60R145CFD7	IPL60R160CFD7	IPP60R145CFD7	IPA60R145CFD7	IPW60R145CFD7
125/140	IPB60R125CFD7		IPL60R140CFD7	IPP60R125CFD7	IPA60R125CFD7	IPW60R125CFD7
105/115	IPB60R105CFD7		IPL60R115CFD7	IPP60R105CFD7		IPW60R105CFD7
90/95	IPB60R090CFD7		IPL60R095CFD7	IPP60R090CFD7		IPW60R090CFD7
70/75	IPB60R070CFD7		IPL60R075CFD7	IPP60R070CFD7		IPW60R070CFD7
55/60	IPB60R055CFD7		IPL60R060CFD7			IPW60R055CFD7
40	IPB60R040CFD7					IPW60R040CFD7
						IPW60R037CSFD
31						IPW60R031CFD7
24						IPW60R024CFD7
18						IPW60R018CFD7

Released replacement for IPW65R041CFD | Coming soon

CoolMOS™ CFD7 to be released in **TOLL, DDPAK & QDPAK**

Discrete offers for bias power supplies

› **Discrete solution** with CoolMOS™ P7 + QR or FF flyback PWM Integrated Controller

P_{out}	$V_{ds,max}$	SOT-223	IPAK
< 12 W	950 V	**IPN95R3K7P7**	IPU95R3K7P7
	800 V	**IPN80R3K3P7**	IPS80R2K4P7
	700 V	**IPN70R2K0P7S**	IPS70R1K4P7S
12 – 15 W	950 V	**IPN95R2K0P7**	IPU95R2K0P7
	800 V	**IPN80R2K0P7**	IPS80R2K4P7
	700 V	**IPN70R2K0P7S**	IPS70R1K4P7S
15 – 20 W	950 V	**IPN95R1K2P7**	IPU95R2K0P7
	800 V	**IPN80R1K4P7**	IPS80R2K0P7
	700 V	**IPN70R1K4P7S**	IPS70R1K4P7S
20 – 25 W	950 V	**IPN95R1K2P7**	IPU95R1K2P7
	800 V	**IPN80R900P7**	IPS80R1K4P7
	700 V	**IPN70R900P7S**	IPS70R1K4P7S

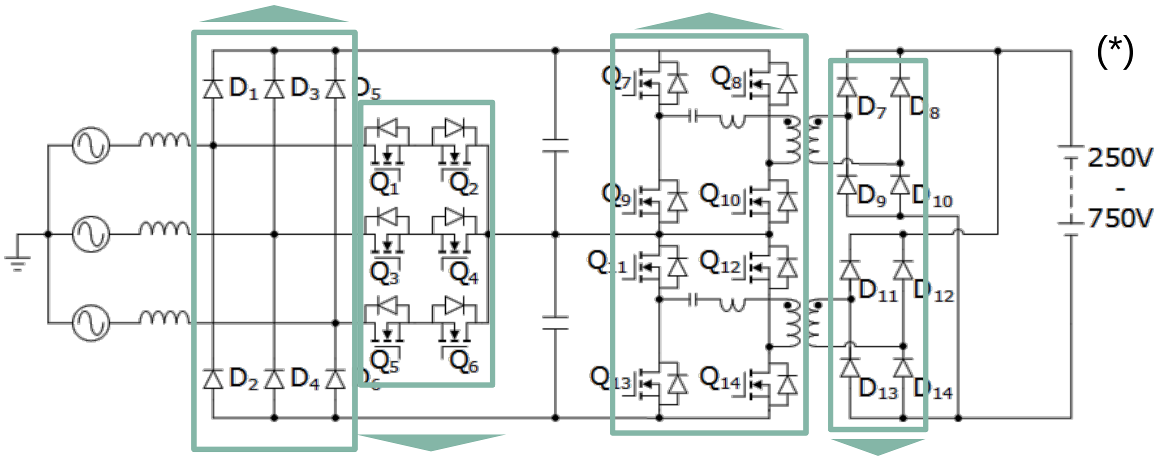
- CoolMOS™ P7 offers finely graduated $R_{DS(on)}$ portfolio
- Cost effective package → SOT-223 offering good thermal performace
- Enabling system solution with QR or FF flyback PWM IC

› **Assumptions:**
› P7 Technology
› DCM operation
› 85% efficiency
› 40°C ambient temp.
› 65kHz fsw
› 100V reflected

Proposed BOM for efficient 20 kW design

12 x 1200 V CoolSiC™ Schottky diode

16 x 600 V CoolMOS™ CFD7



12x 600 V CoolMOS™ P7

16x 650 V CoolSiC™ Schottky diode

Key features and benefits

- High efficiency with Super Junction CoolMOS™ Technology combined with CoolSiC™ Schottky diode
- Suitable for new State Grid standards
- Low design complexity
- Fast time to market

Stage	Switching Freq.	Devices	Product	Part number	Pcs
AC/DC	40 kHz		600 V CoolMOS™ P7	IPW60R037P7	12
			1200 V CoolSiC™ Schottky diode	IDWD20G120C5[2]	12
		Driver IC	EiceDRIVER™ 1ED EiceDRIVER™ 2EDN	1EDI40I12AH **2EDN752**	6 3
DC/DC	up to 300kHz		600 V CoolMOS™ CFD7	IPW60R037CSFD	16
			650 V CoolSiC™ Schottky diode	IDH20G65C6	16
		Driver IC	EiceDRIVER™ 2EDi	2EDS8265H	4
µC			XMC™ 4000 4x PWM Timers	XMC4400-F100K512 BA	2

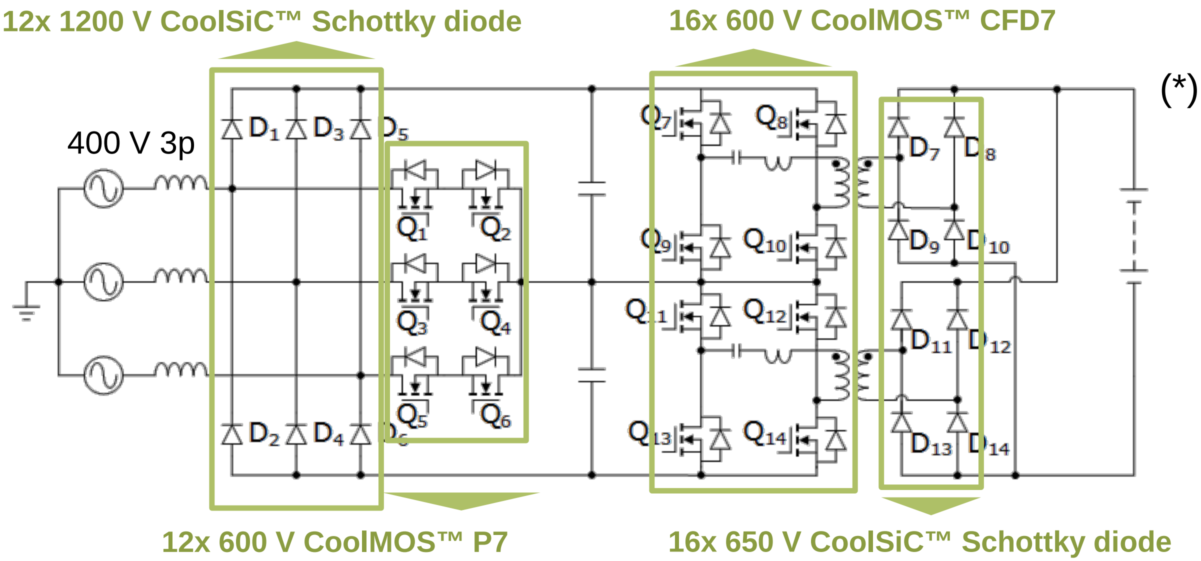
*) Simplified schematic diagram. Symbols for the schematic diagram are only for illustration purposes and does not refer to the proposed bill of material.

Application assumptions

- 50 A max.
- 20 kW, 50 A @400 V
- Air cooled
- Vienna rectifier for PFC
- 2 stacked FB LLC with 2 paralleled MOSFETs
- DC Link Voltage 840 V

[2]) coming soon

Proposed BOM for efficient 30 kW design



Key features and benefits

- High efficiency with super junction CoolMOS™ Technology combined with SiC diode CoolSiC™
- 10 kW increase in power with same BOM
- Low design complexity
- Fast time to market

Stage	Switching Freq.	Devices	Product	Part number	Pcs
AC/DC	40 kHz		600 V CoolMOS™ P7	IPW60R024P7	12
			1200 V CoolSiC™ Schottky diode	IDWD40G120C5[2]	12
		Driver IC	EiceDRIVER™ 1ED EiceDRIVER™ 2EDN	1EDI40I12AH **2EDN752**	6 3
DC/DC	up to 300kHz		600 V CoolMOS™ CFD7	IPW60R024CFD7	16
			650 V CoolSiC™ Schottky diode	IDW40G65C5	16
		Driver IC	EiceDRIVER™ 2EDi	2EDS8265H	8
µC			XMC™ 4000 4x PWM Timers	XMC4400-F100K512 BA	2

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

Application assumptions

- 30 kW, 75 A @400 V
- Air cooled
- Vienna Rectifier for PFC
- 2 stacked 2 interleaved FB LLC
- DC Link Voltage 840 V

[2]) coming soon

Infineon's power solution positioning for EV charger

350 kW modular solutions

up to 150 kW grey zone

≤60 kW discrete solutions

	Discrete solutions	Module solutions
350 kW	Modular solution is recommended	Stacked modular solutions: 6 x 60 kW; 100 kW, 100 kW, 100 kW
120/150 kW	4/5 x 30 kW	Stacked 50 kW modular solutions: 50 kW, 50 kW, 50 kW; EconoDUAL™, EconoPACK™4
50/60 kW	Stacked 20 / 30 kW discrete solutions: 20 kW, 20 kW, 20 kW; 30 kW, 30 kW	Easy CoolSiC™, EconoPACK™4
30 kW*	CoolMOS™ 7, CoolSiC™, IGBT TRENCHSTOP™ 5	Discrete solution is recommended
20 kW*	CoolMOS™ 7, CoolSiC™, IGBT TRENCHSTOP™ 5	Discrete solution is recommended

* DC charger subunit or DC charger

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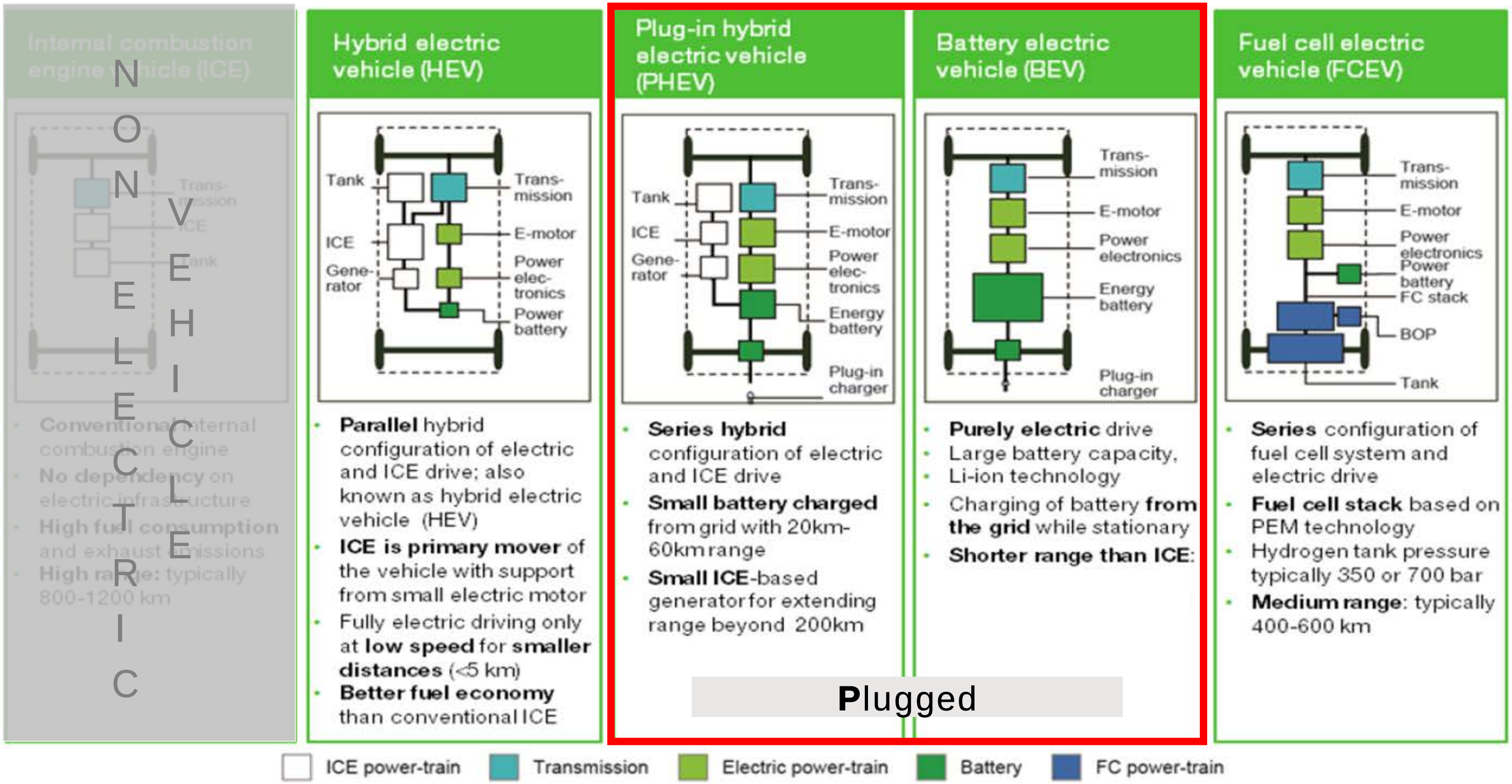
Electric vehicles are split up into 4 parts generally

Differences between electric vehicles

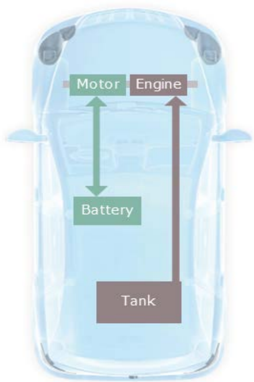


Source: Report Electric_Vehicles_The_quiet_rEVolution_By_Liberum

Onboard Charger is presented in every “Plugged” Vehicle: Battery Electric or Plug In Hybrid Vehicle

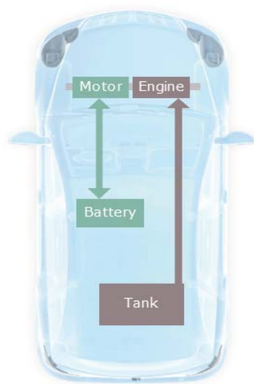
The 4 main electrification systems

48V MHEV



- (+) Low system cost & effort
- (-) Limited CO_2 savings

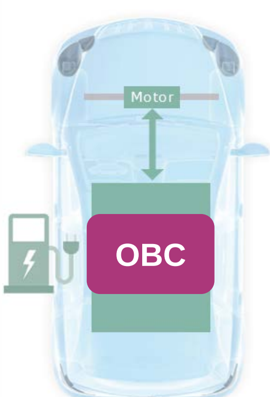
FHEV



- (+) Infrastructure not required
- (-) No credit / incentive

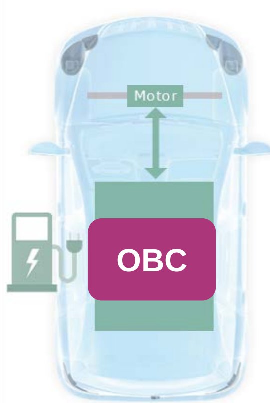
PHEV

Plugged



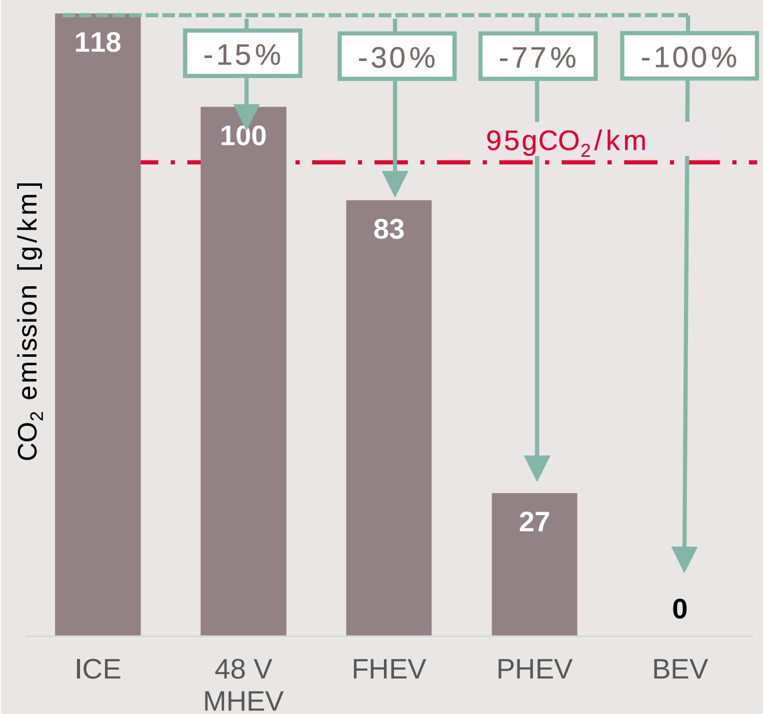
- (+) Electric drive capability
- (-) Complexity of ICE + Battery

BEV



- (+) Full electric drive capability
- (-) Dependent on infrastructure

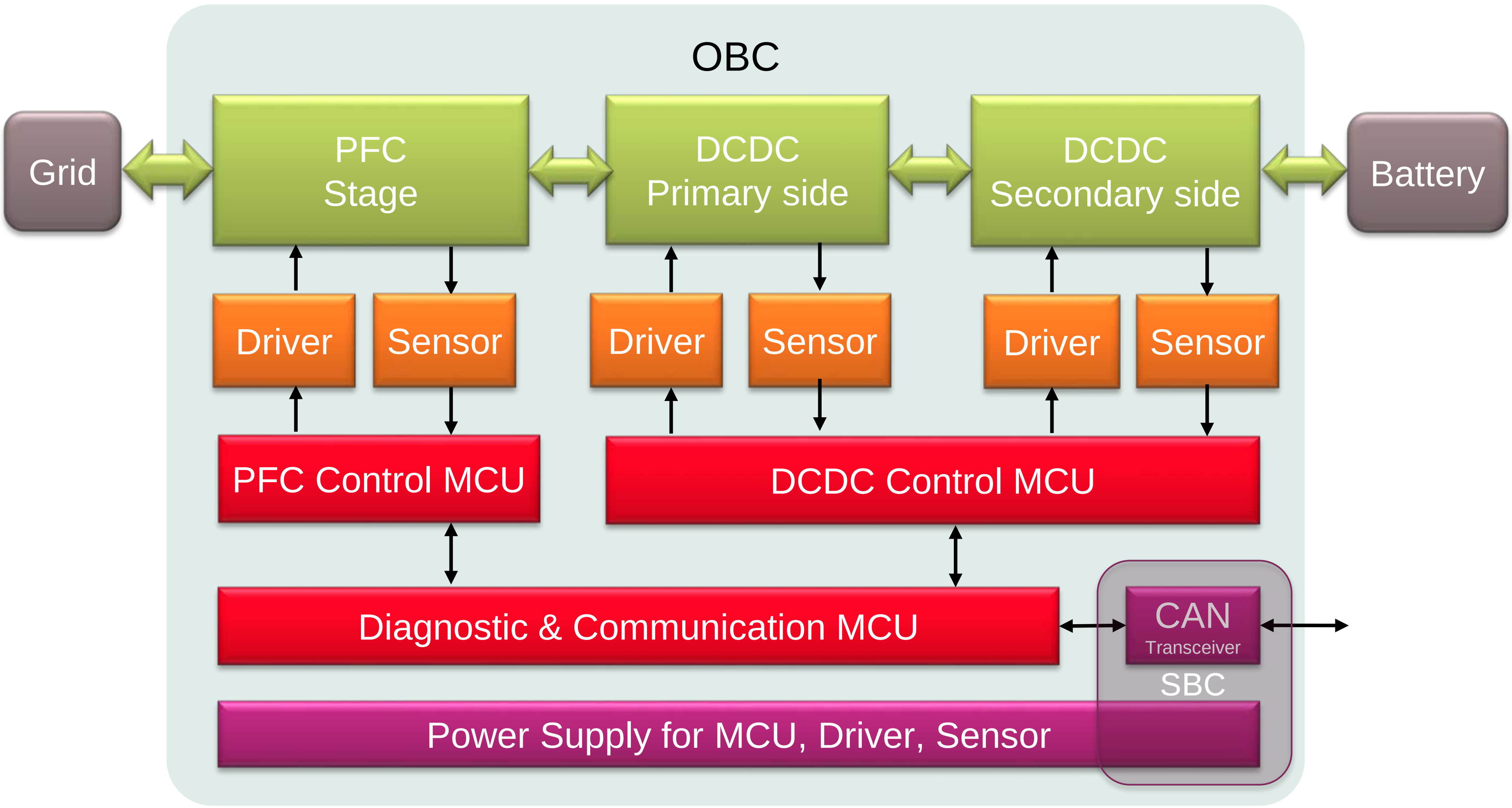
EU Example of emission efficiency



Source: Infineon estimates

All numbers are for 2017

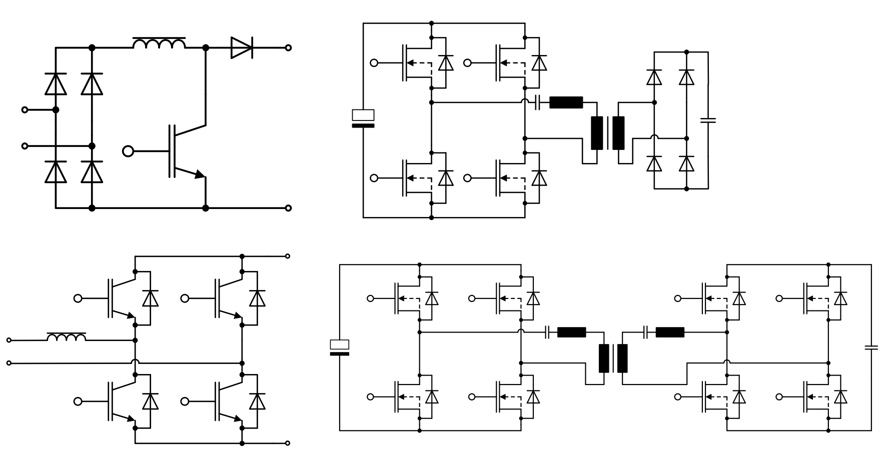
OBC Architecture from semiconductor perspective



Trend and Typical Topologies of OBC Power Stage by using discrete devices*

PFC DCDC

1-Φ designs

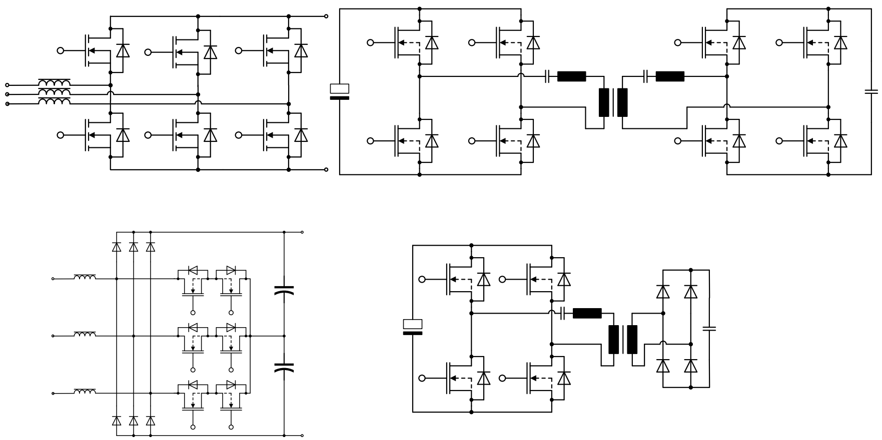


- 3.3kw low cost solution
- Only unidirectional

- 6.6kw mainstream solution
- active rectifier and bi-direction

PFC DCDC

3-Φ designs



- 11kw/22kw 3phase charger
- 3-phase PFC+ CLLC
- 800V or 1200V device needed

- 11kw/22kw 3phase charger
- Vienna rectifier PFC+ LLC
- 650V device may work

*Discrete devices include CoolMOS™ CFDA/CFD7A, Fast IGBT, COPAK and SiC Diode/MOSFET

CoolMOS™ 650V CFDA

1 Reliability for repetitive hard commutation due to fast body diode

BIC reliability with >40% lower reverse recovery charge than competitors

2 Ease of use for fast design-in

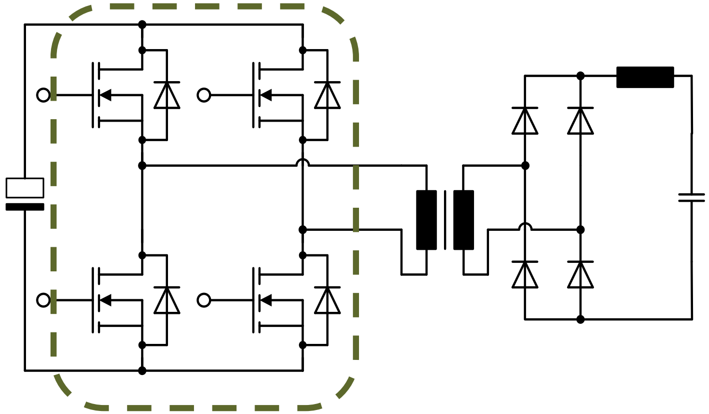
Low voltage overshoot and high safety margin
Low ringing and gate spikes
Good controllability with broad range of R_g

3 Design flexibility

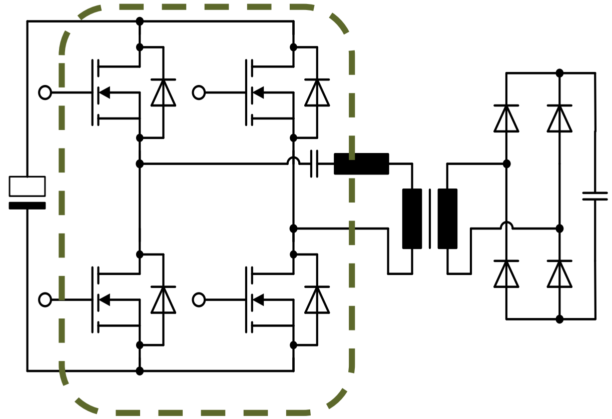
Available in standard TO- and SMD-packages in application relevant $R_{DS(ON)}$ classes

Topology Example:

› Phase Shift Full Bridge

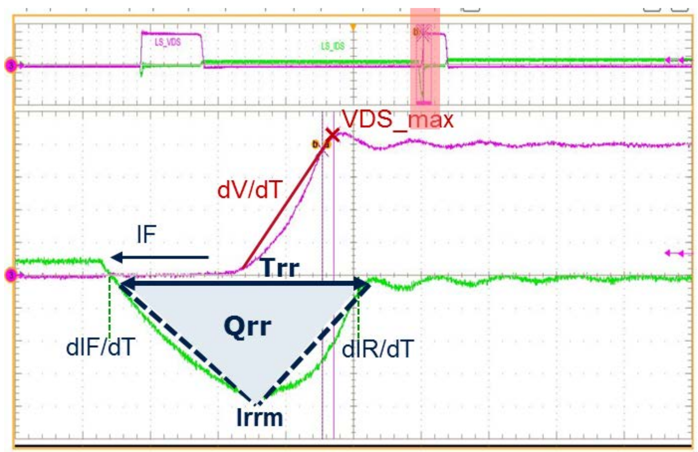


› Full bridge LLC



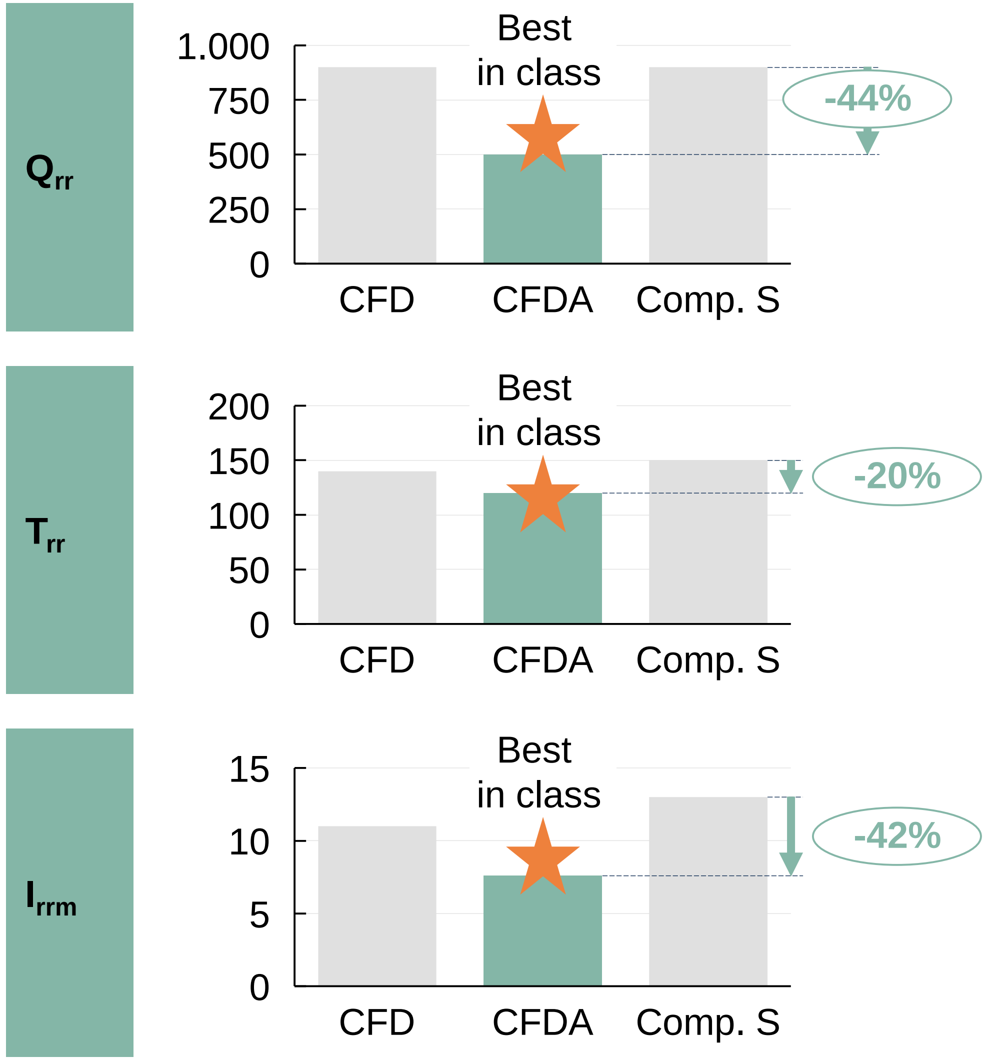
CoolMOS™ CFDA offers highest reliability under hard commutation

Customer need – fast recovery



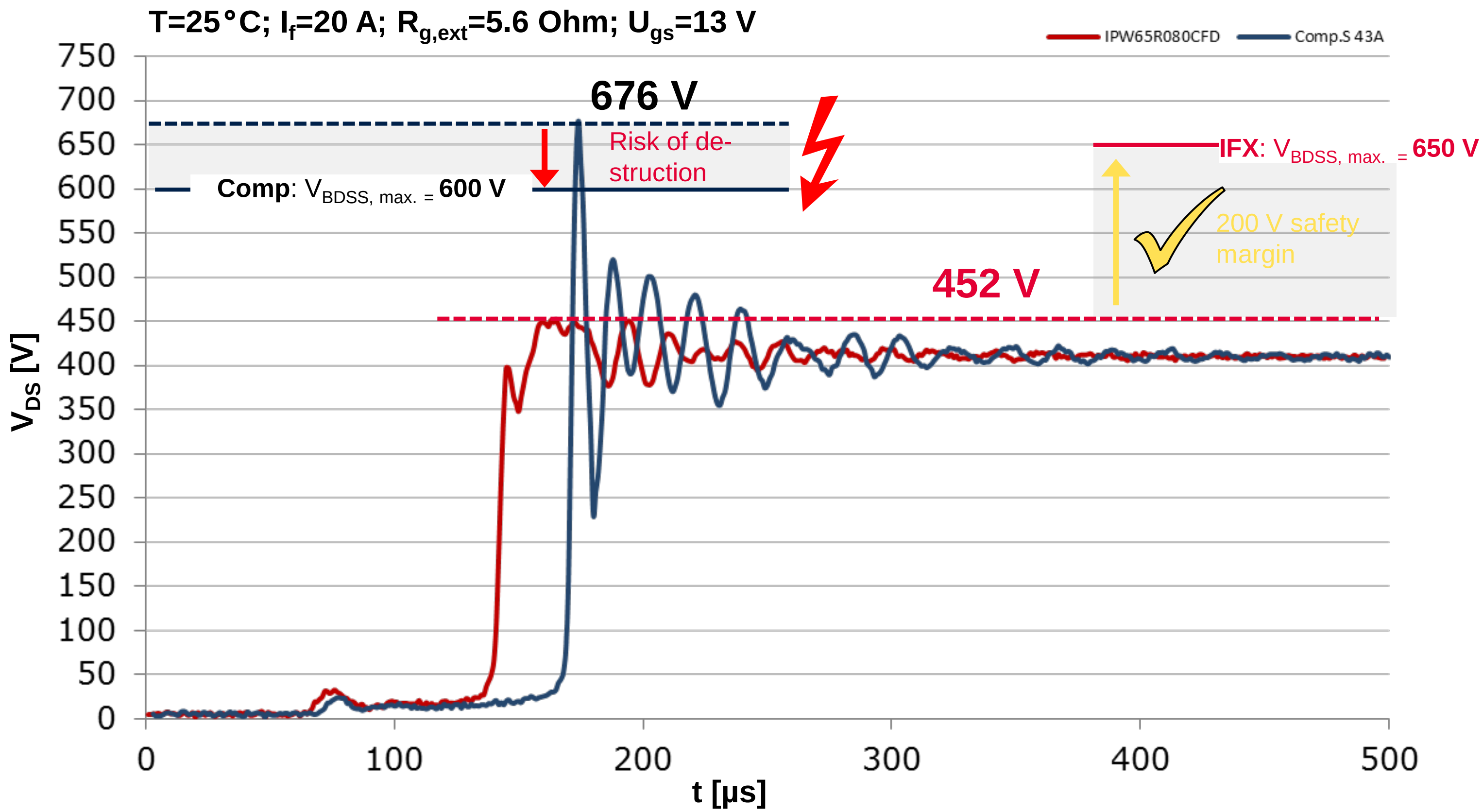
CFDA is the **most robust and fastest body diode** on the market

CFDA benefit – lowest Q_{rr}, T_{rr}, I_{rrm}



CoolMOS™ CFDA comes with lowest voltage overshoot and 200 V safety margin

Hard commutation of body diode at >1000 A/µs



Voltage overshoot

Large safety margin of ~200 V from

- Low voltage overshoot
- Higher V_{BDSS} of 650 V
- Competition with high voltage overshoot – risk of destruction

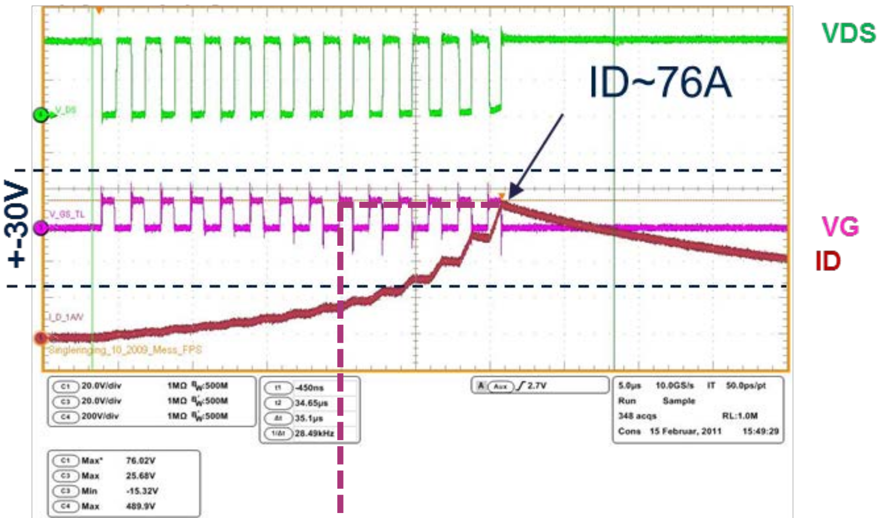
Ringing

Smooth switching behavior

- Fast design-in due to no extra effort for ringing control needed

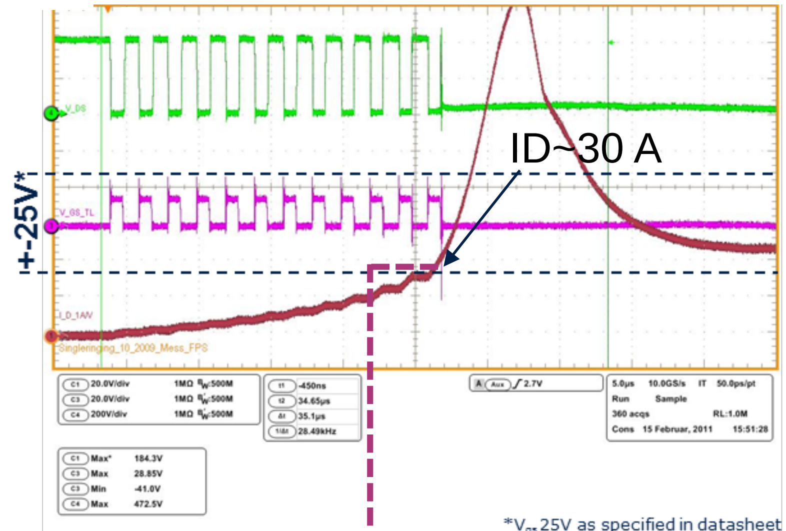
CoolMOS™ CFDA with very low ringing and gate spiking

IPP65R190CFDA



CFD2 enables higher ID until device reaches saturation

Competition S



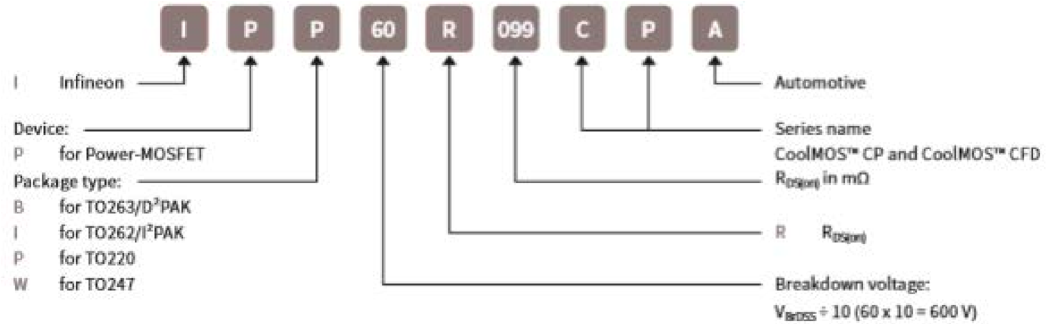
Vgs spec. violation at 30 A

- Gate peak voltage is an indicator for ringing behavior
- **Self limiting di/dt and dv/dt** leads to
  - Less voltage overshoot
  - Less ringing (ease of design-in)

CoolMOS™ CFDA lead products for OBC & DC-DC Application

CoolMOS™ CFDA for resonant switching

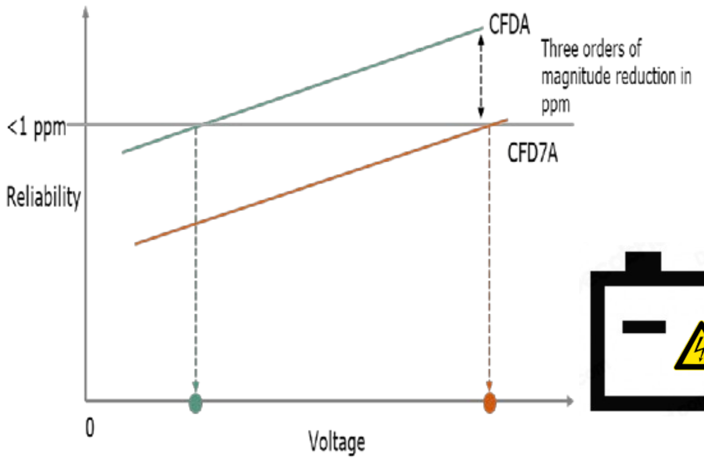
Part Number	BV(V)	Rdson(mΩ)	Fast body diode	Package	Status
IPW65R048CFDA	650	48	Yes	TO-247	Released
IPW65R080CFDA	650	80	Yes	TO-247	Released
IPW65R110CFDA	650	110	Yes	TO-247	Released
IPW65R150CFDA	650	150	Yes	TO-247	Released
IPW65R190CFDA	650	190	Yes	TO-247	Released
IPP65R110CFDA	650	110	Yes	TO-220	Released
IPP65R150CFDA	650	150	Yes	TO-220	Released
IPP65R190CFDA	650	190	Yes	TO-220	Released
IPP65R310CFDA	650	310	Yes	TO-220	Released
IPP65R660CFDA	650	660	Yes	TO-220	Released
IPB65R110CFDA	650	110	Yes	TO-263	Released
IPB65R150CFDA	650	150	Yes	TO-263	Released
IPB65R190CFDA	650	190	Yes	TO-263	Released
IPB65R310CFDA	650	310	Yes	TO-263	Released
IPB65R660CFDA	650	660	Yes	TO-263	Released
IPD65R420CFDA	650	420	Yes	TO-252	Released
IPD65R660CFDA	650	660	Yes	TO-252	Released

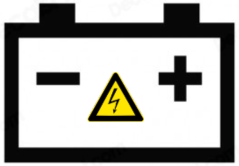


CoolMOS™ 650V CFD7A

① Technology robustness

Higher application voltages possible (at same proven reliability level)



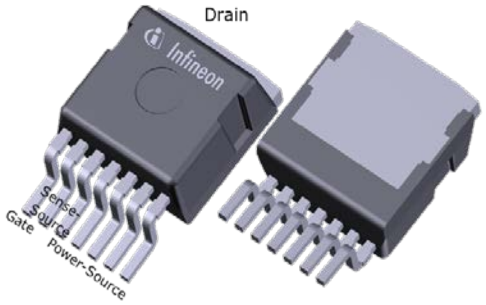


400V⟶475V

② SMD packages

D2PAK 7-pin with increased creepage distance and Kelvin source

QDPAK top-side cooled

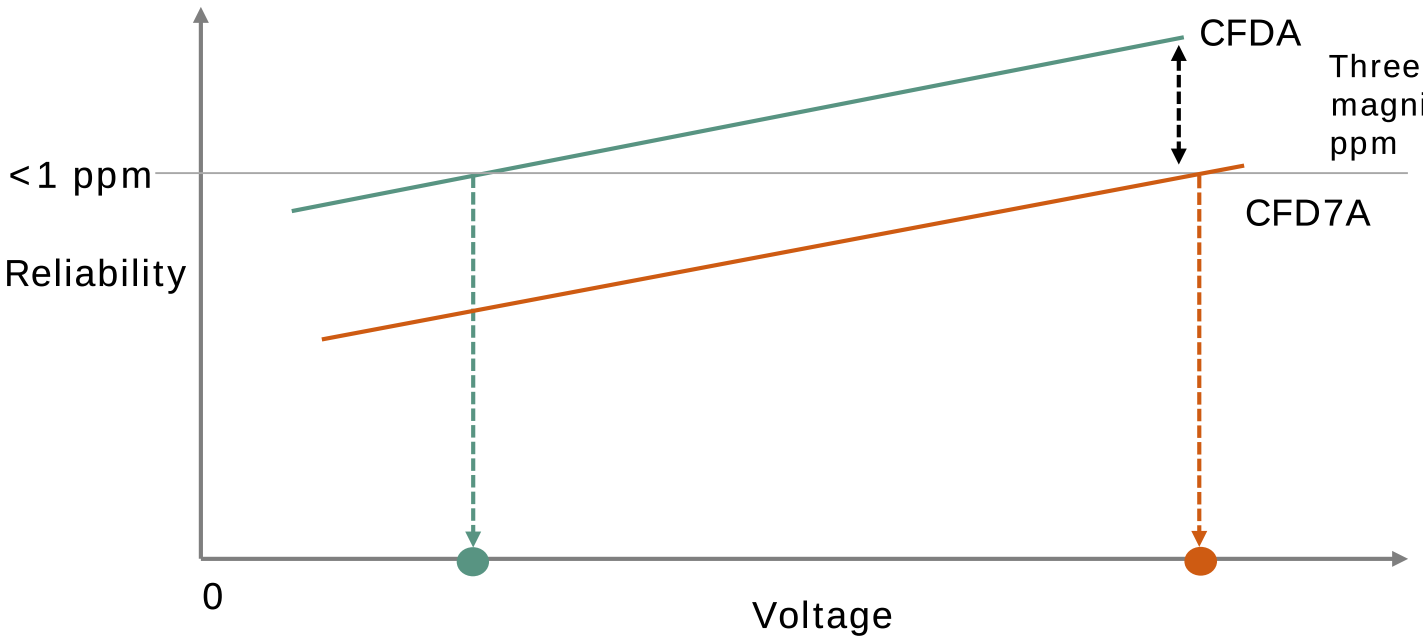


③ One part for soft and hard switching (economies of scale)

Considerable improvement in key parameters (higher efficiency)

First product already available (IPB65R115CFD7A)

CFD7A enables higher application voltages at same reliability level*



CFD7A enables

- *considerable FIT rate improvement* (at same application voltage) or
- *higher application voltages* (at same ppm rate) compared to CFDA

*Schematic representation, real-life benefits depend on individual customer use profile

CoolMOS™ CFD7A lead products for OBC & DC-DC Application

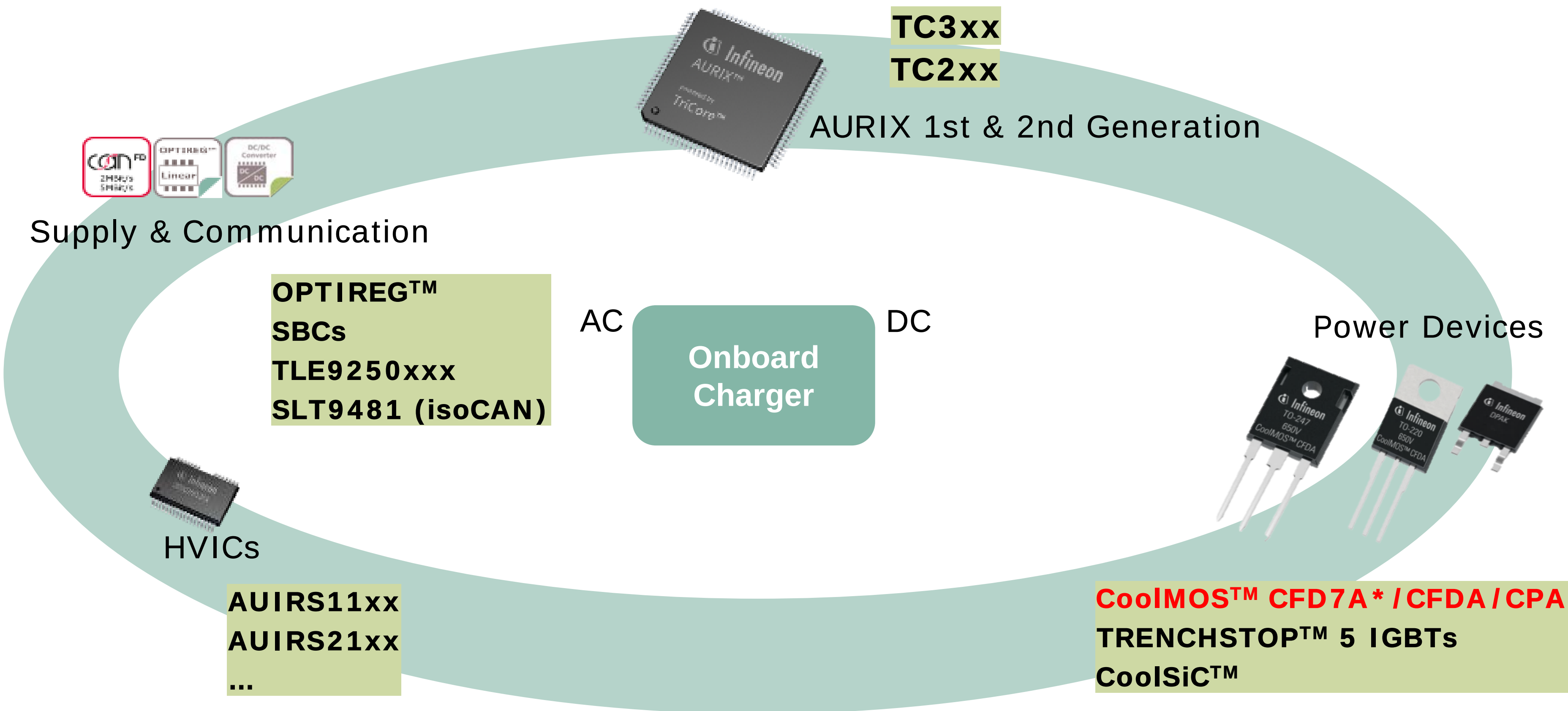
CoolMOS™ CFD7A for hard and resonant switching

Part Number	BV(V)	Rdson (mΩ)	Fast body diode	Package	Status
IPW65R115CFD7A	650	115	Yes	TO-247 (THD)	ES Jan 2020
IPW65R099CFD7A	650	99	Yes	TO-247 (THD)	ES Mar 2020
IPW65R075CFD7A	650	75	Yes	TO-247 (THD)	ES Mar 2020
IPW65R050CFD7A	650	50	Yes	TO-247 (THD)	ES Jan 2020
IPW65R035CFD7A	650	35	Yes	TO-247 (THD)	ES Mar 2020
IPW65R022CFD7A	650	22	Yes	TO-247 (THD)	ES Jan 2020
IPBE65R115CFD7A	650	115	Yes	D2PAK 7-pin	ES available
IPBE65R099CFD7A	650	99	Yes	D2PAK 7-pin	ES Feb 2020
IPBE65R075CFD7A	650	75	Yes	D2PAK 7-pin	ES Feb 2020
IPBE65R050CFD7A	650	50	Yes	D2PAK 7-pin	ES Feb 2020
IPB65R115CFD7A	650	115	Yes	D2PAK 3-pin	Released
IPB65R050CFD7A	650	50	Yes	D2PAK 3-pin	ES Jan 2020

Further Rdsons and packages available is coming

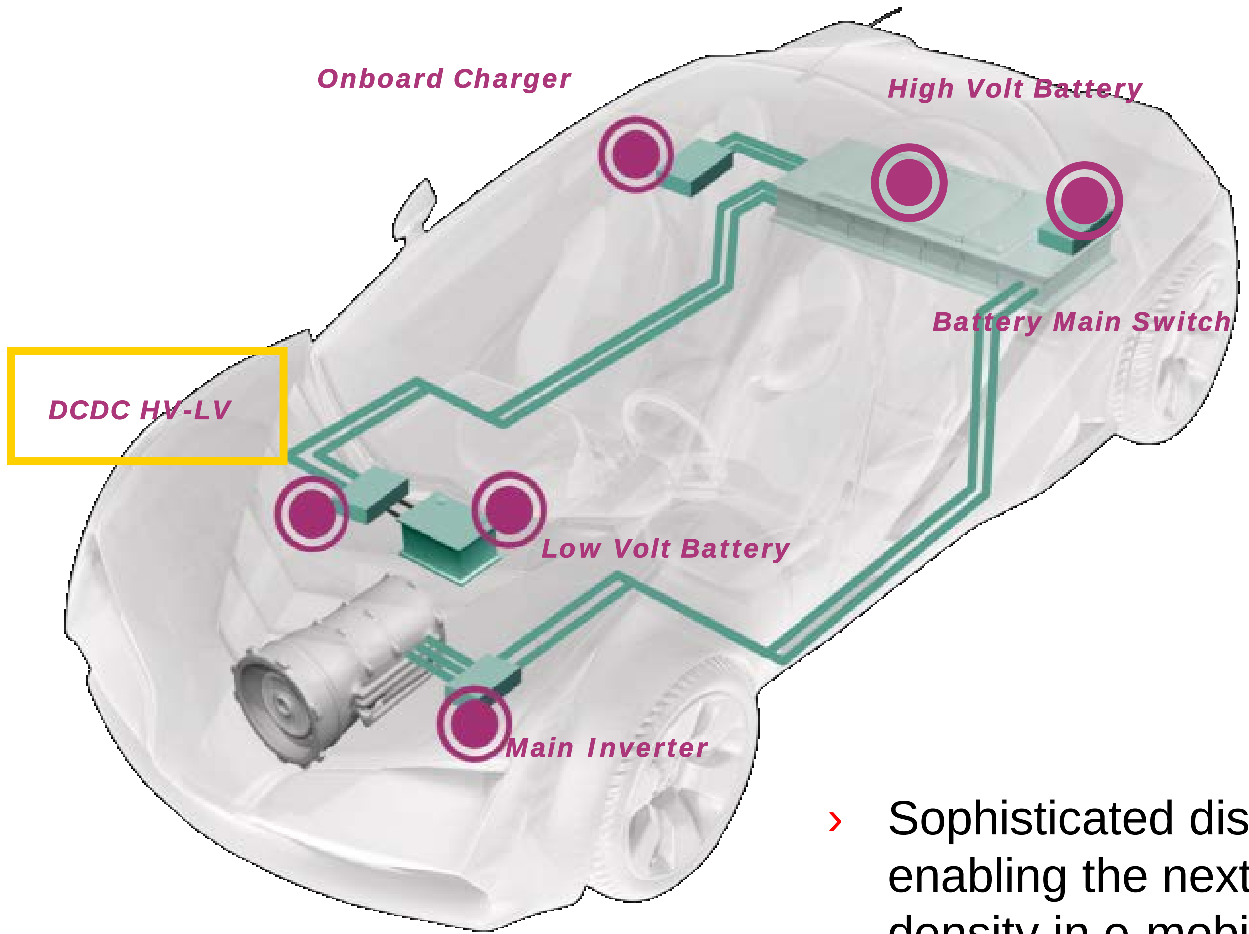
Infineon has the Complete Semiconductor Solution

All solutions for all Kinds of Implementations for OBCs



*Under development

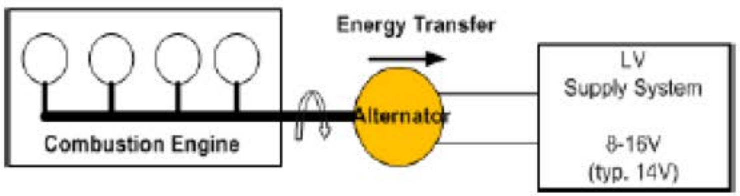
About DCDC in automotive applications



- Sophisticated discrete devices enabling the next level of power density in e-mobility applications

Trend and typical requirement on DC_DC

Conventional Cars

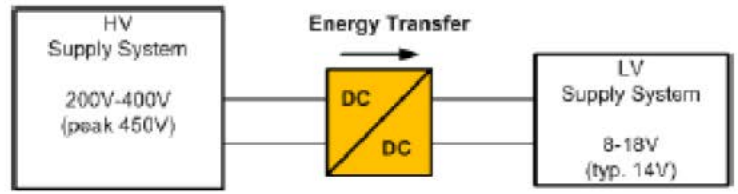


Alternator:

+ Low cost
+ Established technology

– Efficiency (mechanical & electrical)
– Feedback to combustion engine!
– Energy transfer availability
– Weight

HEV, PHEV, EV

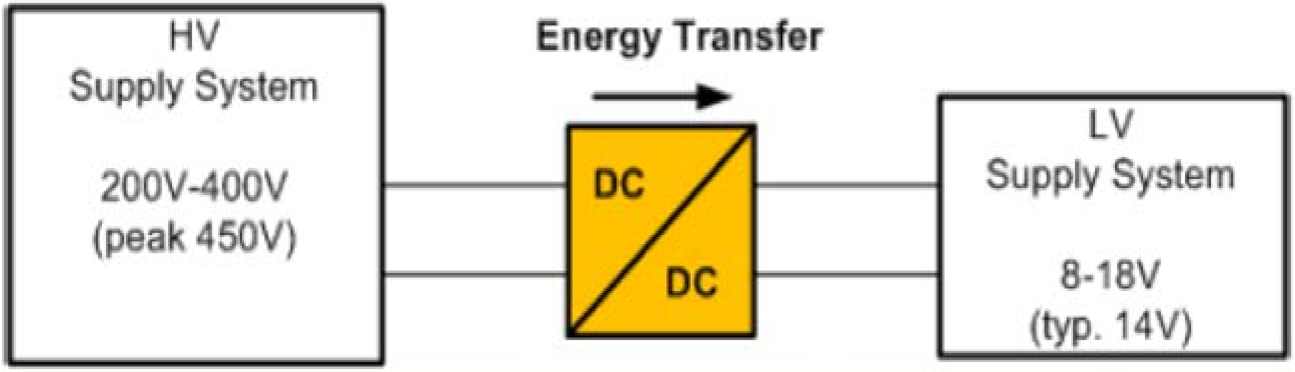


DC/DC-Converter:

+ Weight
+ Efficiency
+ No feedback on main traction
+ Energy transfer availability

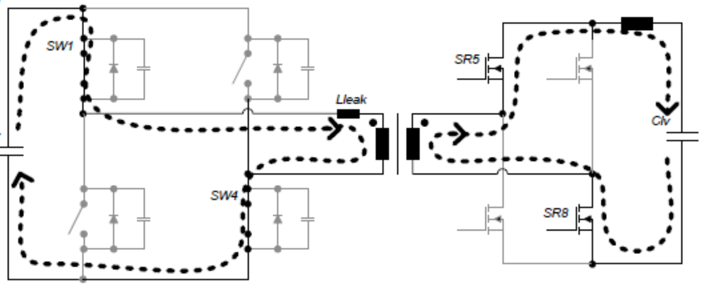
– Cost & Complexity

Typical specification on DC_DC

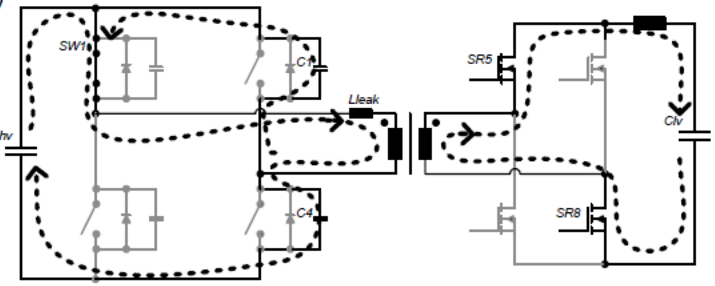


Description	min	typ	max
Input voltage	200V	300V	400V (450V peak)
Output voltage	8V	14V	16-18V
Output current			200A
Power transfer		400-800W	3kW
Switching frequency		100kHz	
Efficiency	0%	>90%	
Isolation		basic	

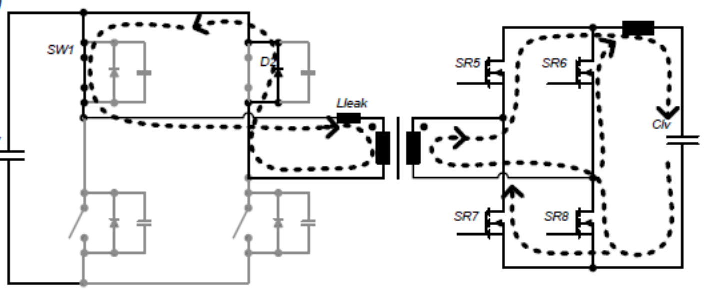
A)



B)

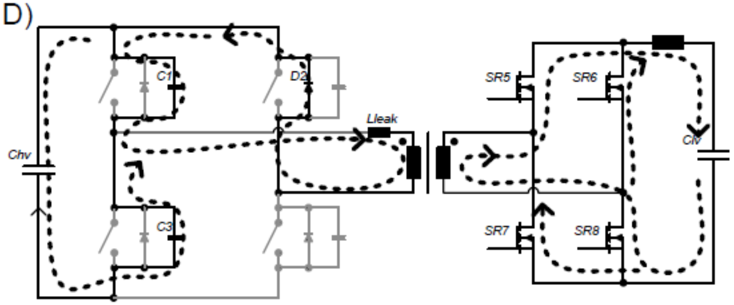


C)

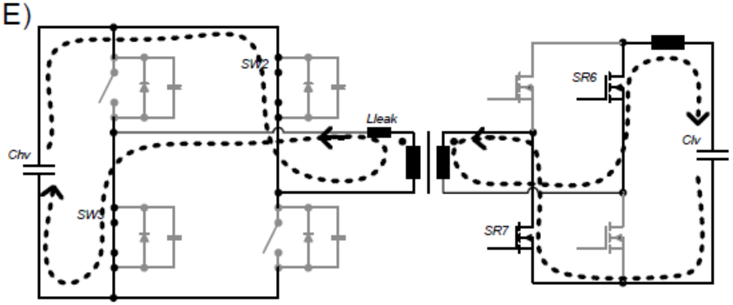


A: Energy Transfer (half cycle positive)
B: Right Leg Transition (during dead time)
C: Free Wheeling (half cycle)
D: Left Leg Transition (during dead time)
E (similar to A): Energy Transfer (half cycle negative)
F (similar to B): Right Leg Transition (during dead time)
G (similar to C): Free Wheeling (half cycle)
H (similar to D): Left Leg Transition (during dead time)
A: Energy Transfer (half cycle positive)

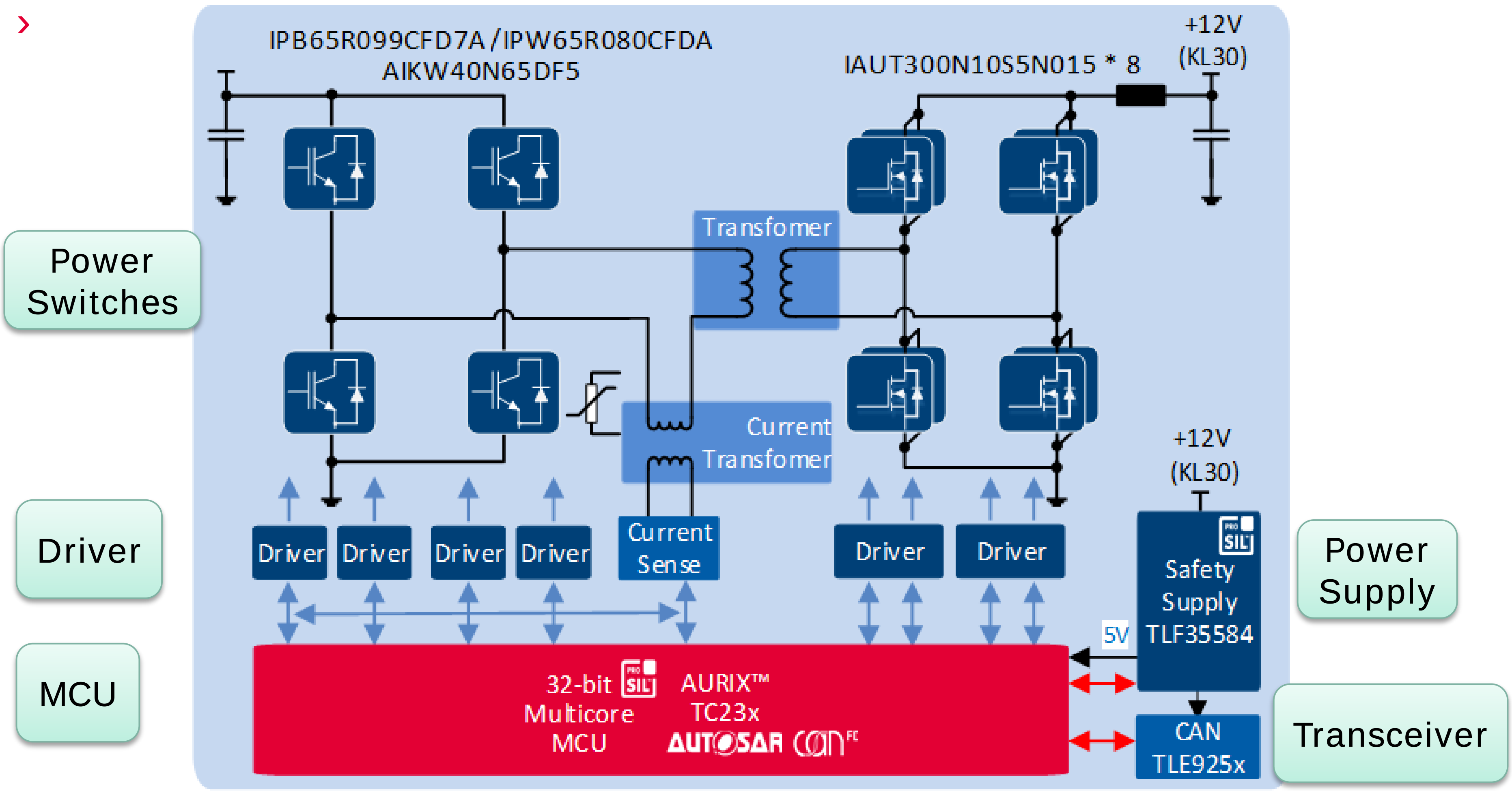
D)



E)



Block Diagram of HV-LV DCDC



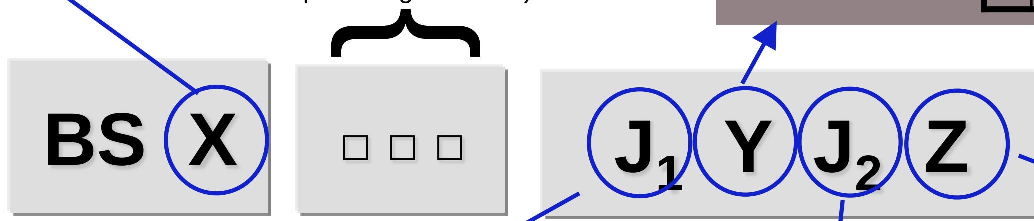
In HV side : 650V discrete devices is suggested
In LV sides : 80V/100V TOLL & TOLG is available

SMALL SIGNAL and P-Channel MOSFETs Naming System

„X“
INDICATES THE PACKAGE

D	SOT-363
P	SOT-223
R	SC59
S	SOT-89, SOT-23, SOT323
L	TSOP-6

3 digits product identifier (meaning dependent on product generation)



„Y“
INDICATES THE POLARITY

N	N-channel
P	P-channel
C	Complementary (= n-ch + p-ch)

„Z“
INDICATES ADDITIONAL FEATURES

E	ESD protected MOSFET

„J_1“
PRESENT ONLY IN THE FOLLOWING CASE:

S	SINGLE (only for packages which are also used for multichip products)

„J_2“
PRESENT ONLY IN THE FOLLOWING CASE:

W	To distinguish SOT-323 from SOT-23

HOW CAN I RECOGNIZE IF A PART IS A SINGLE OR A MULTICHIP PRODUCT?

TSOP-6 and SOT-363 can be single or multichip products.
If they are used for single products then “J_1”=S (ex. BSL207**S**P)
If they are used for multichip products then “J_1” is not present (ex. BSD235N).

IS IT POSSIBLE TO CONFUSE SOT-23, SOT-89, SOT-323 BECAUSE THEY HAVE THE SAME “X”?
No.
SOT-89 is an exposed-pad package, the other two not.
SOT-323 has in addition “J_2”=W, while the SOT-23 does not.

N-Channel MOSFETs

Voltage	Product name	$R_{DS(on)}$ @ 10 V [mΩ]	I_D [A]	$V_{GS(th)}$ (min–max) [V]	Q_G (typ) [nC]	Technology	Package[1]
20 V	BSR202N	21[3]	3.80	0.70 ... 1.20	5.80	OptiMOS™2	SC59
	BSL202SN	22[3]	7.50	0.70 ... 1.20	5.80	OptiMOS™2	TSOP-6/6
	BSR802N	23[3]	3.70	0.30 ... 0.75	4.70	OptiMOS™2	SC59
	BSS205N	50[3]	2.50	0.70 ... 1.20	2.10	OptiMOS™2	SOT23
	BSL806N	57[3]	2.30	0.30 ... 0.75	1.70	OptiMOS™2	TSOP-6/6 dual
	BSS806N	57[3]	2.30	0.30 ... 0.75	1.70	OptiMOS™2	SOT23
	BSS214N	140[3]	1.50	0.70 ... 1.20	0.80	OptiMOS™2	SOT23
	BSS214NW	140[3]	1.50	0.70 ... 1.20	0.80	OptiMOS™2	SOT323
	BSD214SN	140[3]	1.50	0.70 ... 1.20	0.80	OptiMOS™2	SOT363
	BSS816NW	160[3]	1.40	0.30 ... 0.75	0.60	OptiMOS™2	SOT323
	BSD816SN	160[3]	1.40	0.30 ... 0.95	0.60	OptiMOS™2	SOT363
	BSD235N	350[3]	0.95	0.70 ... 1.20	0.32	OptiMOS™2	SOT363 dual
	BSD840N	400[3]	0.88	0.30 ... 0.75	0.26	OptiMOS™2	SOT363 dual
30 V	BSS306N	57	2.30	1.20 ... 2.00	1.50	OptiMOS™2	SOT23
	BSS316N	160	1.40	1.20 ... 2.00	0.60	OptiMOS™2	SOT23
	BSD316SN	160	1.40	1.20 ... 2.00	0.60	OptiMOS™2	SOT363
55 V	BSS670S2L	650	0.54	1.20 ... 2.00	1.70	OptiMOS™	SOT23
60 V	BSS606N	60	3.20	1.30 ... 2.30	3.70	OptiMOS™3	SOT89
	BSL606SN	60	4.50	1.30 ... 2.30	3.70	OptiMOS™3	TSOP-6/6
	BSP318S	90	2.60	1.20 ... 2.00	14.00	SIPMOS™	SOT223
	BSP320S	120	2.90	2.10 ... 4.00	9.70	SIPMOS™	SOT223
	BSP295	300	1.80	0.80 ... 1.80	14.00	SIPMOS™	SOT223
	2N7002DW	3000	0.30	1.50 ... 2.50	0.40	OptiMOS™	SOT363 dual
	BSS138N	3500	0.23	0.60 ... 1.40	1.00	SIPMOS™	SOT23
	BSS138W	3500	0.28	0.60 ... 1.40	1.00	SIPMOS™	SOT223
	SN7002N	5000	0.20	0.80 ... 1.80	1.00	SIPMOS™	SOT23
	BSS7728N	5000	0.20	1.30 ... 2.30	1.00	SIPMOS™	SOT23
	SN7002W	5000	0.23	0.80 ... 1.80	1.00	SIPMOS™	SOT323
100 V	BSP372N	230	1.80	0.80 ... 1.80	9.50	OptiMOS™	SOT223
	BSP373N	240	1.80	2.10 ... 4.00	6.20	OptiMOS™	SOT223
	BSP296N	600	1.20	0.80 ... 1.80	4.50	OptiMOS™	SOT223
	BSS123N	6000	0.19	0.80 ... 1.80	0.60	OptiMOS™	SOT23
	BSS119N	6000	0.19	1.30 ... 2.30	0.60	OptiMOS™	SOT23
200 V	BSP297	1800	0.66	0.80 ... 1.80	12.90	SIPMOS™	SOT223
240 V	BSP89	6000	0.35	0.80 ... 1.80	4.30	SIPMOS™	SOT223
	BSP88	6000	0.35	0.60 ... 1.40	4.50	SIPMOS™	SOT223
	BSS87	6000	0.26	0.80 ... 1.80	3.70	SIPMOS™	SOT89
	BSS131	14,000	0.11	0.80 ... 1.80	2.10	SIPMOS™	SOT23
400 V	BSP298	3000	0.50	2.10 ... 4.00	–	SIPMOS™	SOT223
	BSP324	25,000	0.17	1.30 ... 2.30	4.50	SIPMOS™	SOT223
500 V	BSP299	4000	0.40	2.10 ... 4.00	–	SIPMOS™	SOT223
600 V	BSP125	45,000	0.120	1.30 ... 2.30	4.40	SIPMOS™	SOT223
	BSS225	45,000	0.090	1.30 ... 2.30	3.90	SIPMOS™	SOT89
	BSS127	500,000	0.021	1.40 ... 2.60	1.40	SIPMOS™	SOT23
800 V	BSP300	20,000	0.190	2.00 ... 4.00	–	SIPMOS™	SOT223

P-Channel MOSFETs

Voltage	Product name	$R_{DS(on)}$ @ 10 V [mΩ]	I_D [A]	$V_{GS(th)}$ (min–max) [V]	Q_G (typ) [nC]	Technology	Package[1]
-20 V	BSL207SP	41[2]	-6.00	-1.20 ... -0.60	-13.30	OptiMOS™ P	TSOP-6/6
	BSL211SP	67[2]	-4.70	-1.20 ... -0.60	-8.30	OptiMOS™ P	TSOP-6/6
	BSL215P	150[2]	-1.50	-1.20 ... -0.60	-3.55	OptiMOS™ P2	TSOP-6/6 dual
	BSS215P	150[2]	-1.50	-1.20 ... -0.50	-3.60	OptiMOS™ P2	SOT23
	BSV236SP	175[2]	-1.50	-1.20 ... -0.60	-3.80	OptiMOS™ P	SOT363
	BSS209PW	550[2]	-0.63	-1.20 ... -0.60	-1.00	OptiMOS™ P	SOT323
	BSS223PW	1,200[2]	-0.39	-1.20 ... -0.60	-0.50	OptiMOS™ P	SOT323
	BSD223P	1,200[2]	-0.39	-1.20 ... -0.60	-0.50	OptiMOS™ P	SOT363
-30 V	BSL307SP	43	-5.50	-2.00 ... -1.00	-23.40	OptiMOS™ P	TSOP-6/6 dual
	BSL308PE	80	-2.00	-2.00 ... -1.00	-5.00	OptiMOS™ P3 + integrated ESD diode	TSOP-6/6 dual
	BSS308PE	80	-2.00	-2.00 ... -1.00	-5.00	OptiMOS™ P3 + integrated ESD diode	SOT23
	BSS314PE	140	-1.50	-2.00 ... -1.00	-2.90	OptiMOS™ P3 + integrated ESD diode	SOT23
	BSD314SPE	140	-1.50	-2.00 ... -1.00	-2.90	OptiMOS™ P3 + integrated ESD diode	SOT363
	BSS315P	150	-1.50	-2.00 ... -1.00	-2.30	OptiMOS™ P2	SOT23
-60 V	BSP613P	130	-2.90	-4.00 ... -2.10	-22.00	SIPMOS™	SOT223
	BSP170P	300	-1.90	-4.00 ... -2.10	-10.00	SIPMOS™	SOT223
	BSP171P	300	-1.90	-2.00 ... -1.00	-13.00	SIPMOS™	SOT223
	BSP315P	800	-1.17	-2.00 ... -1.00	-5.20	SIPMOS™	SOT223
	BSR315P	800	-0.62	-2.00 ... -1.00	-4.00	SIPMOS™	SC59
	BSS83P	2000	-0.33	-2.00 ... -1.00	-2.38	SIPMOS™	SOT23
	BSS84P	8000	-0.17	-2.00 ... -1.00	-1.00	SIPMOS™	SOT23
	BSS84PW	8000	-0.15	-2.00 ... -1.00	-1.00	SIPMOS™	SOT323
-100 V	BSP322P	800	-1.00	-2.00 ... -1.00	-12.40	SIPMOS™	SOT223
	BSP321P	900	-0.98	-4.00... -2.10	-9.00	SIPMOS™	SOT223
	BSP316P	1800	-0.68	-2.00 ... -1.00	-5.10	SIPMOS™	SOT223
	BSR316P	1800	-0.36	-2.00 ... -1.00	-3.00	SIPMOS™	SC59
-250 V	BSR92P	11	-0.14	-2.00 ... -1.00	-3.60	SIPMOS™	SC59
	BSP92P	12	-0.26	-2.00 ... -1.00	-4.30	SIPMOS™	SOT223
	BSS192P	12	-0.19	-2.00 ... -1.00	-4.90	SIPMOS™	SOT89
	BSP317P	4000	-0.43	-2.00 ... -1.00	-11.60	SIPMOS™	SOT223

Complementary and Depletion MOSFETs

Complementary MOSFETs

Voltage	Product name	$R_{DS(on)}$ (max) @ V_{GS} = 10 V [mΩ]	I_D [A]	$V_{GS(th)}$ (min-max) [V]	Q_G (typ) [nC]	Technology	Package[1]
20 V	BSL215C/n-ch	140[2]	1.50	0.70 … 1.20	0.73	OptiMOS™2	TSOP-6/6
-20 V	BSL215C/p-ch	150[2]	-1.50	-1.20 … -0.60	-3.00	OptiMOS™ P2	TSOP-6/6
20 V	BSD235C/n-ch	350[2]	0.95	-1.20 … -0.60	0.34	OptiMOS™2	SOT363
-20 V	BSD235C/p-ch	1200[2]	-0.53	0.70 … 1.20	-0.40	OptiMOS™ P2	SOT363
20 V	BSZ15DC02KD/n-ch	55[2]	5.10	0.80 … 1.40	2.10	OptiMOS™2	TSDSON-8
-20 V	BSZ15DC02KD/p-ch	150[2]	-3.20	-1.40 … -0.70	-3.00	OptiMOS™ P2	TSDSON-8
30 V	BSL316C/n-ch	160	1.40	1.20 … 2.00	0.60	OptiMOS™2	TSOP-6/6
-30 V	BSL316C/p-ch	150	-1.50	-2.00 … -1.00	-2.40	OptiMOS™ P2	TSOP-6/6
30 V	BSL308C/n-ch	57	2.30	1.20 … 2.00	1.50	OptiMOS™2	TSOP-6/6
-30 V	BSL308C/p-ch	80	-2.00	-2.00 … -1.00	-5.00	OptiMOS™ P3	TSOP-6/6

Depletion MOSFETs

Voltage	Product name	$R_{DS(on)}$ (max) @ V_{GS} = 10 V [mΩ]	I_D [A]	Q_G (typ) [nC]	Technology	Package[1]
60 V	BSS159N	8,000	0.230	2.20	SIPMOS™	SOT23
100 V	BSS169	12,000	0.170	2.10	SIPMOS™	SOT23
200 V	BSP149	3,500	0.660	11.00	SIPMOS™	SOT223
240 V	BSP129	6,000	0.350	3.80	SIPMOS™	SOT223
250 V	BSS139	30,000	0.100	2.30	SIPMOS™	SOT23
400 V	BSP179	24,000	0.210	4.50	SIPMOS™	SOT223
600 V	BSP135	60,000	0.120	3.70	SIPMOS™	SOT223
	BSS126	700,000	0.021	1.40	SIPMOS™	SOT23

Agenda

1 Driving Force of EV Charging

2 DC EV Charging Solution

3 OBC and DC/DC Solution for EV

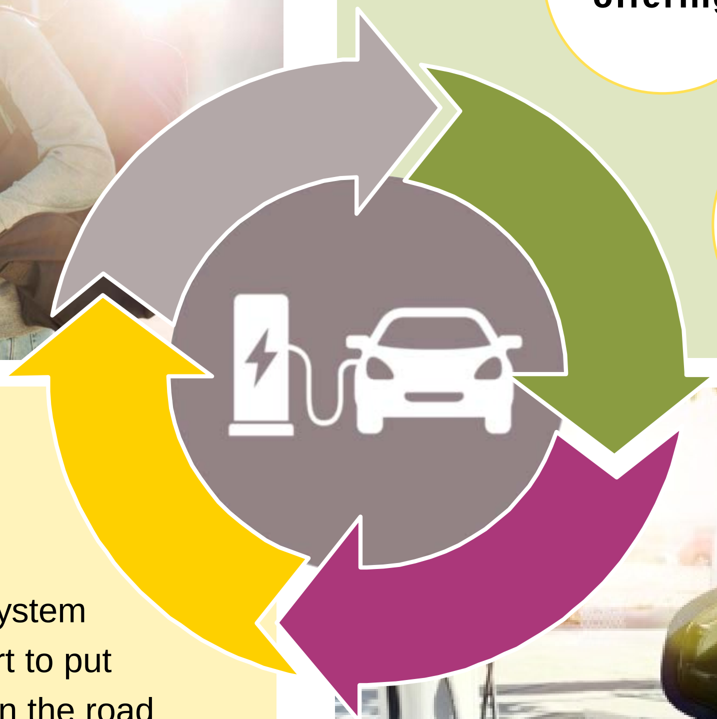
4 Summary

Choose Infineon to solve your EV charging design requirements

Complete offering

System expertise

Unmatched scale



Benefit from optimal system solution at reduced effort to put your EV charging design on the road

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