Introduction on xEV automotive AC/DC, DC/DC solution and CoolMOS™ CFDA

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xEV Market Overview

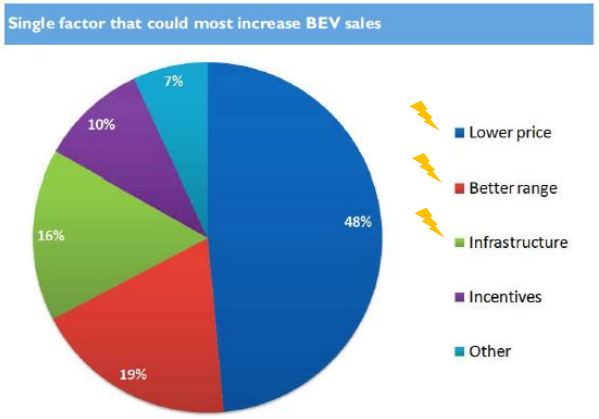
The longest market experience

xEV Market Overview

- Market Projection
  - By 2018, global vehicle production reaches 106Mu with fastest growth in emerging regions; More optimistic outlook for PHEV
  - By 2020, out of global sales of 115m cars, around 10% are xEV; Conventional hybrids with biggest share
  - xEV & ASDA are drivers for electronics system growth; 48V system adoption boost demand further

- For Wide xEV Adoption, Areas-to-Improve
  - Prices (Battery Prices, xEV vs. Alternatives)
  - Range (Expect MIN 200–300KM/charge)
  - Recharging (Infrastructure, Time < 1 hr.)

- Efficiency & Power Density are Keys-to-Success



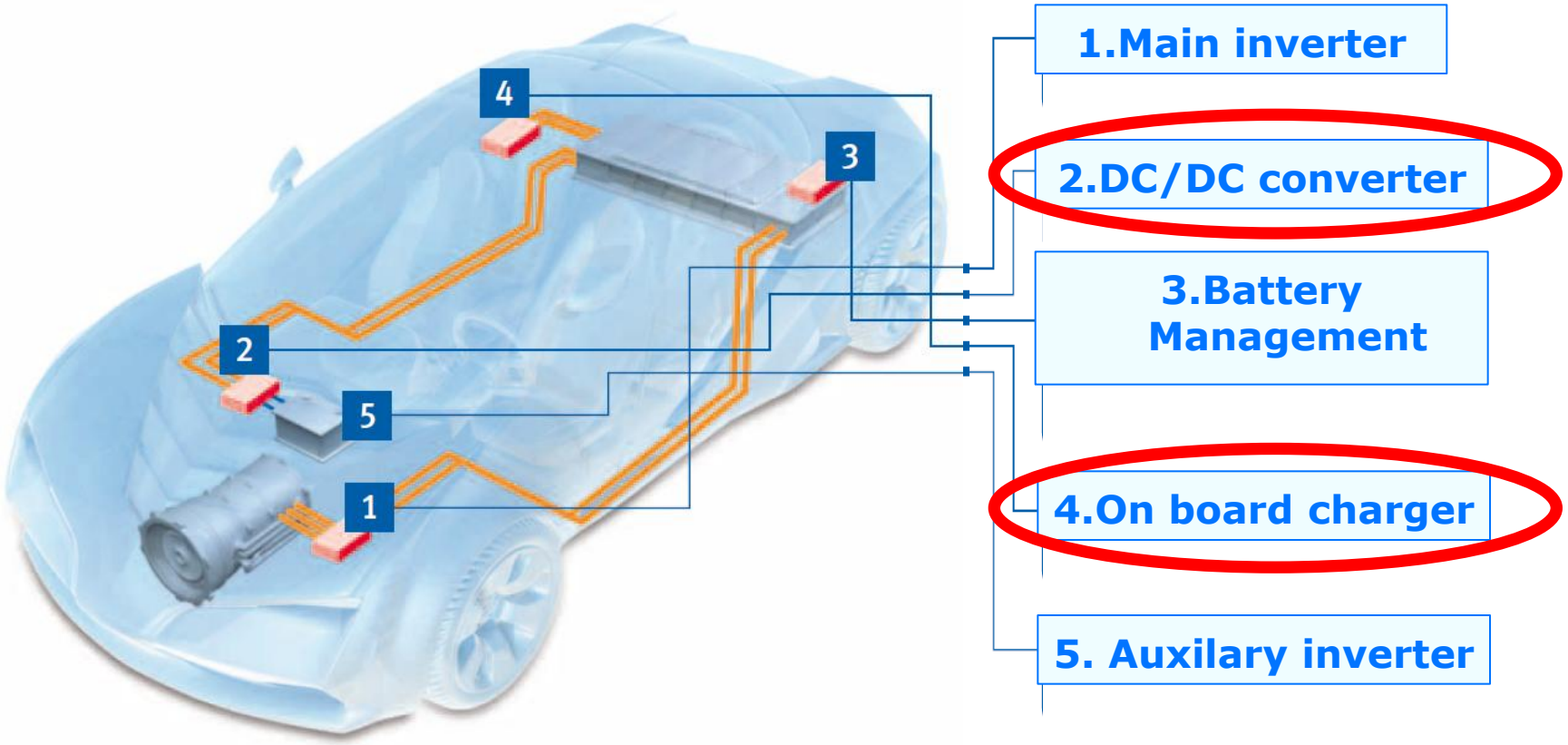
Research by Automotive World

ASDA (Advanced Driver Assistance Systems) : ex. E-Call, Telematics

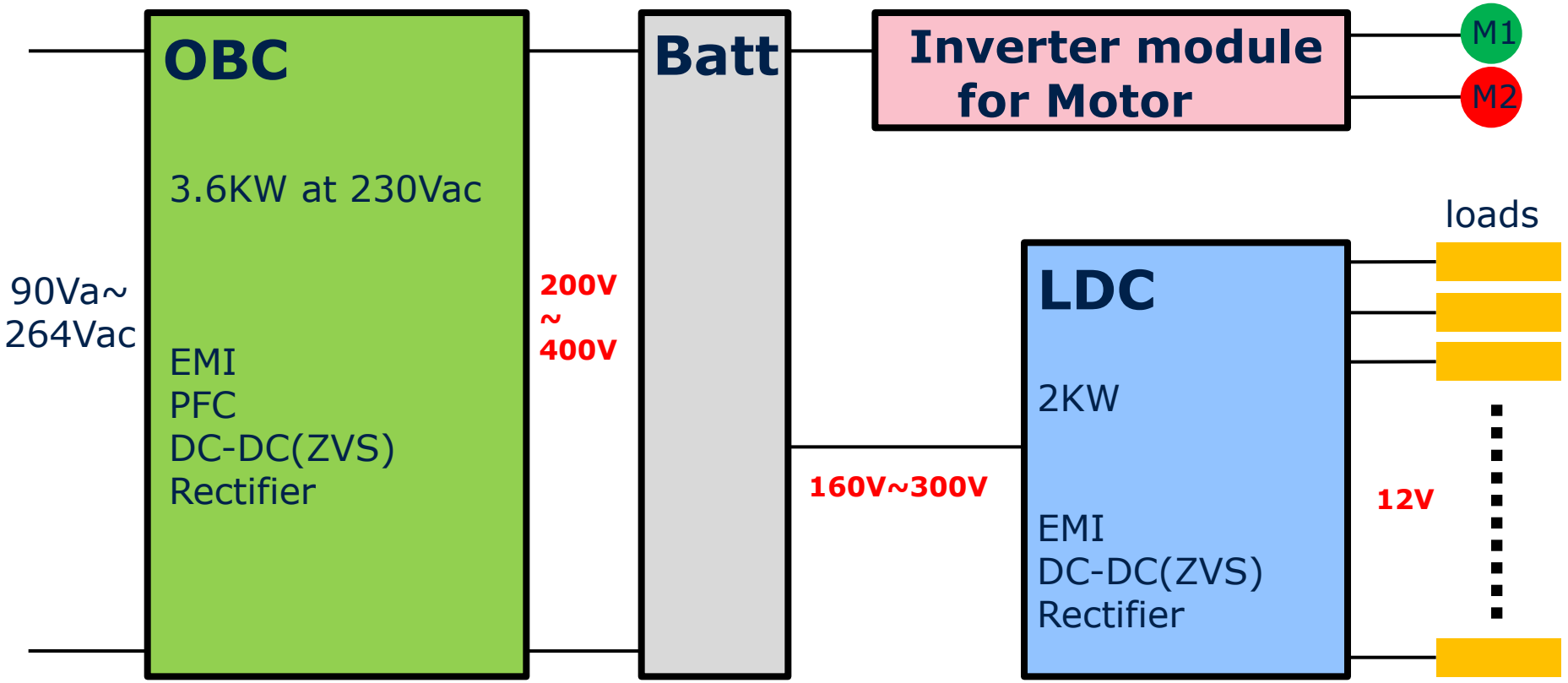
General Overview of xEV

The longest market experience

General Overview of xEV



Block diagram of xEV converter system

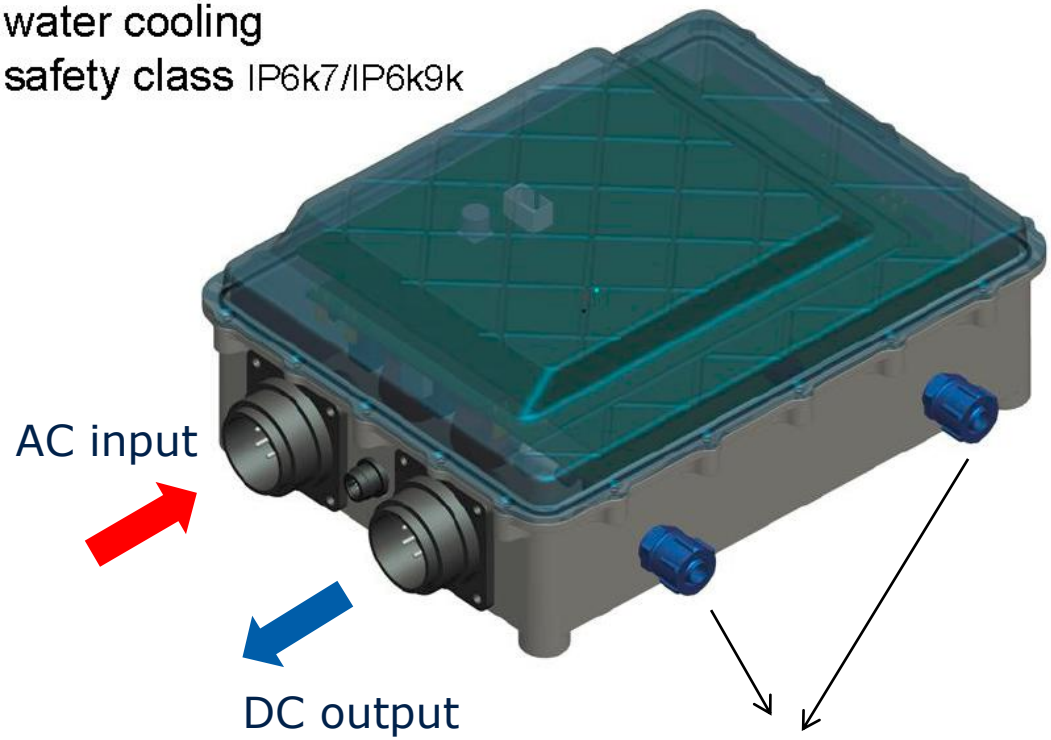


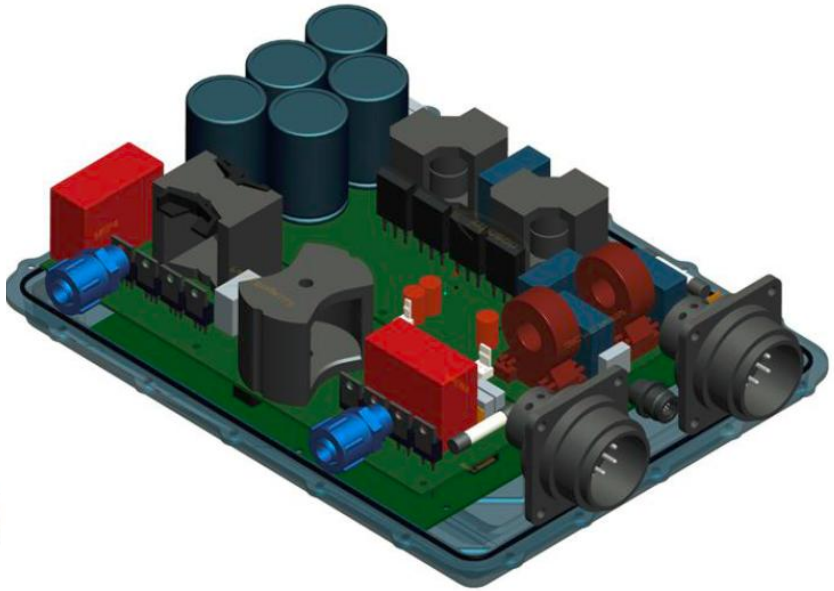
Automotive OBC(On Board Charger) solution

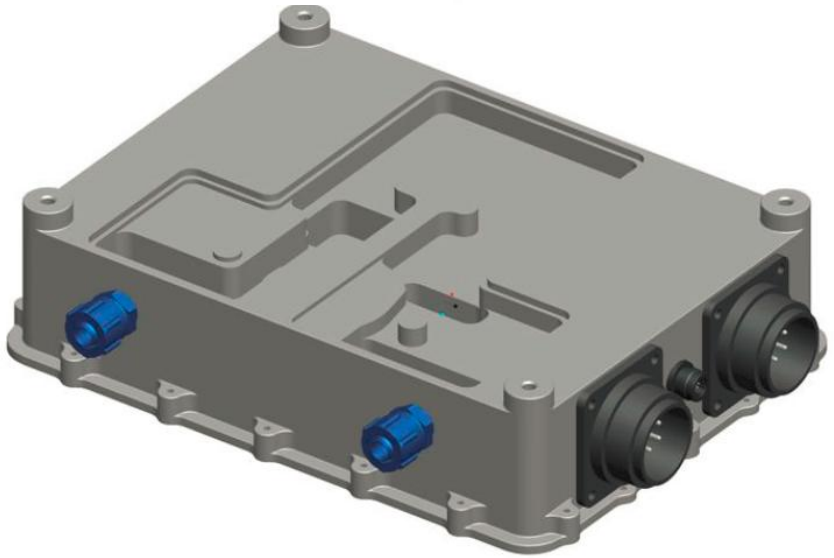
The longest market experience

Infineon OBC solution : Housing, Simulated Aspect

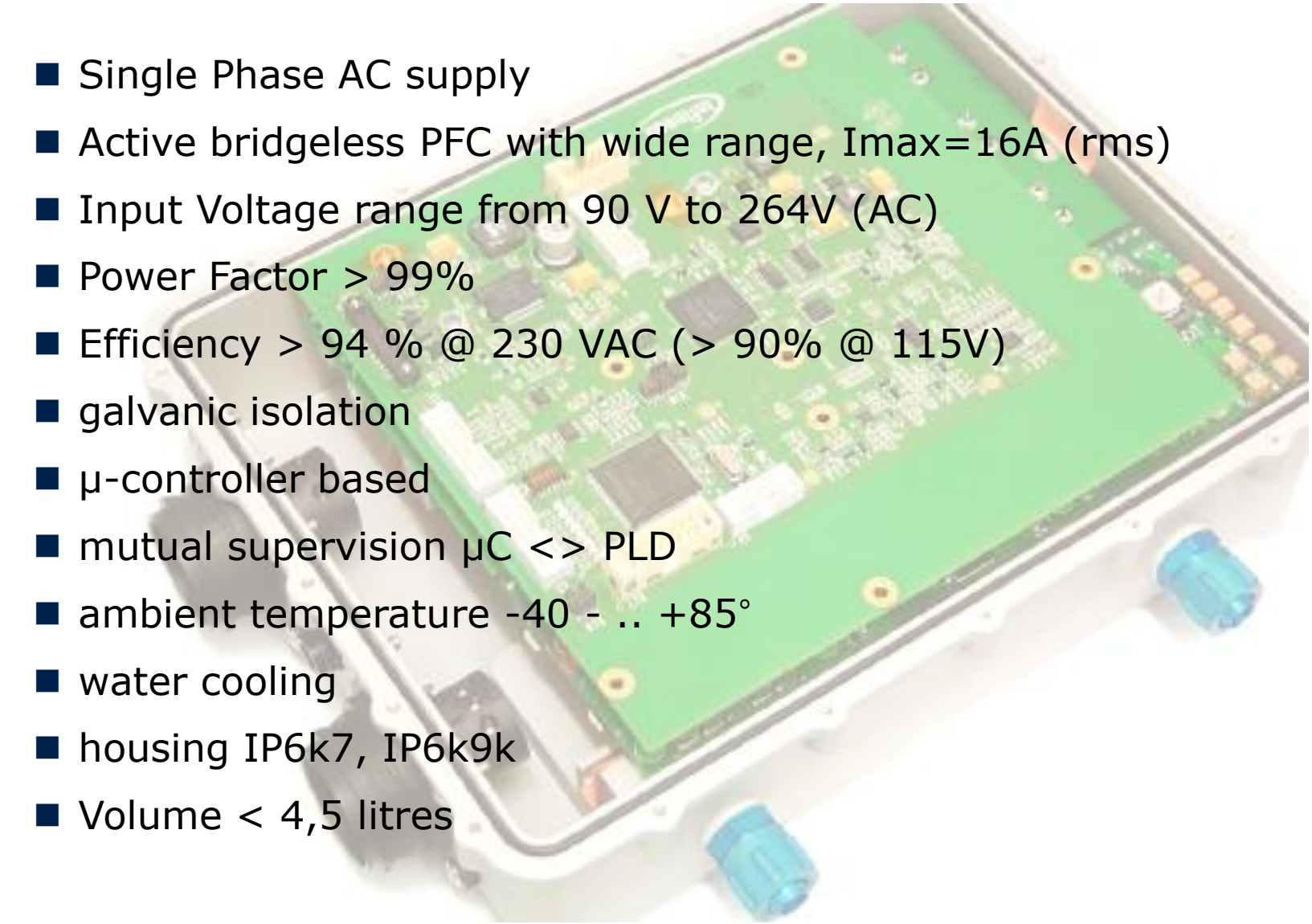
volume below 4 litres
water cooling
safety class IP6k7/IP6k9k





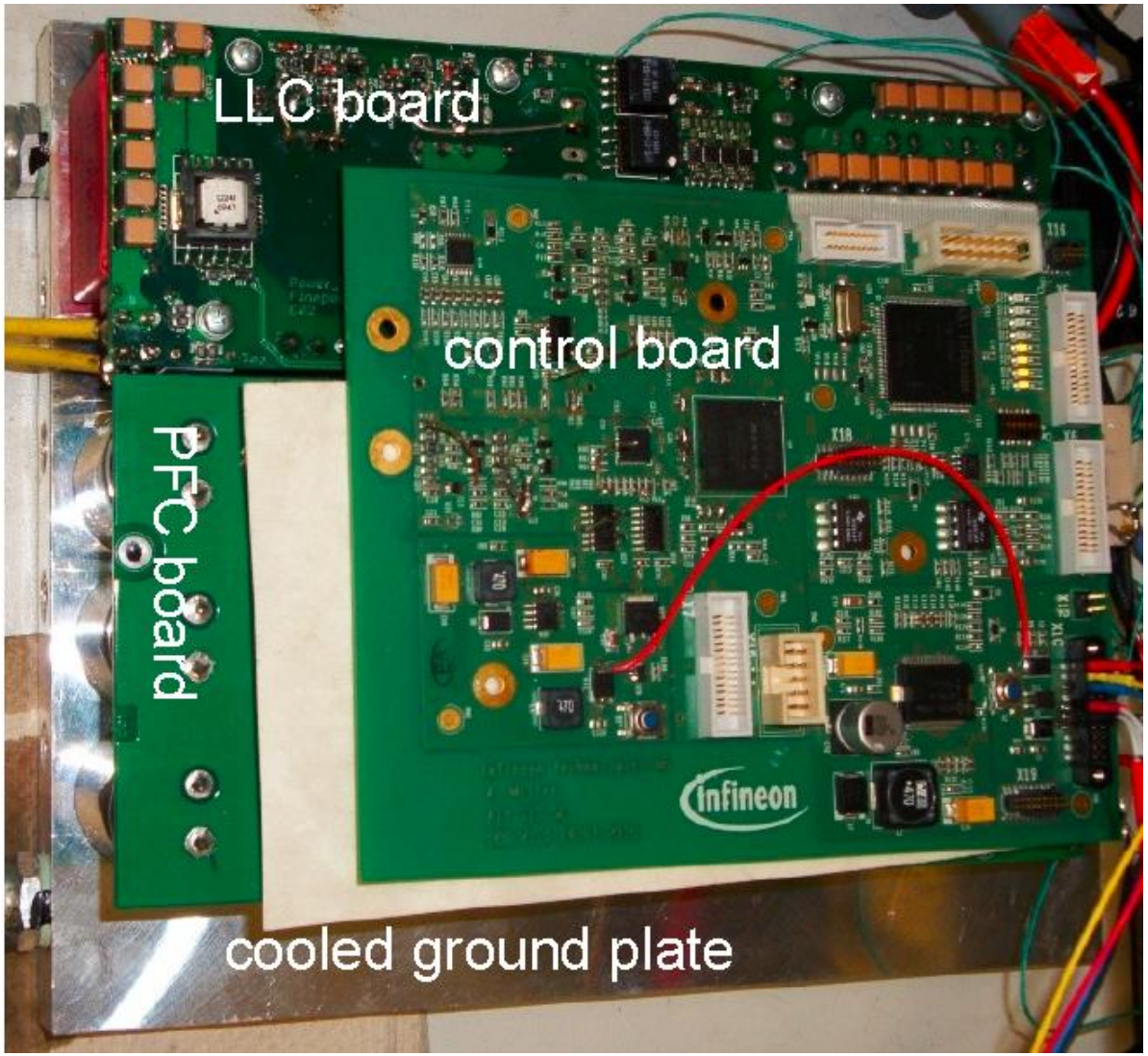


Infineon OBC solution, Target Spec.

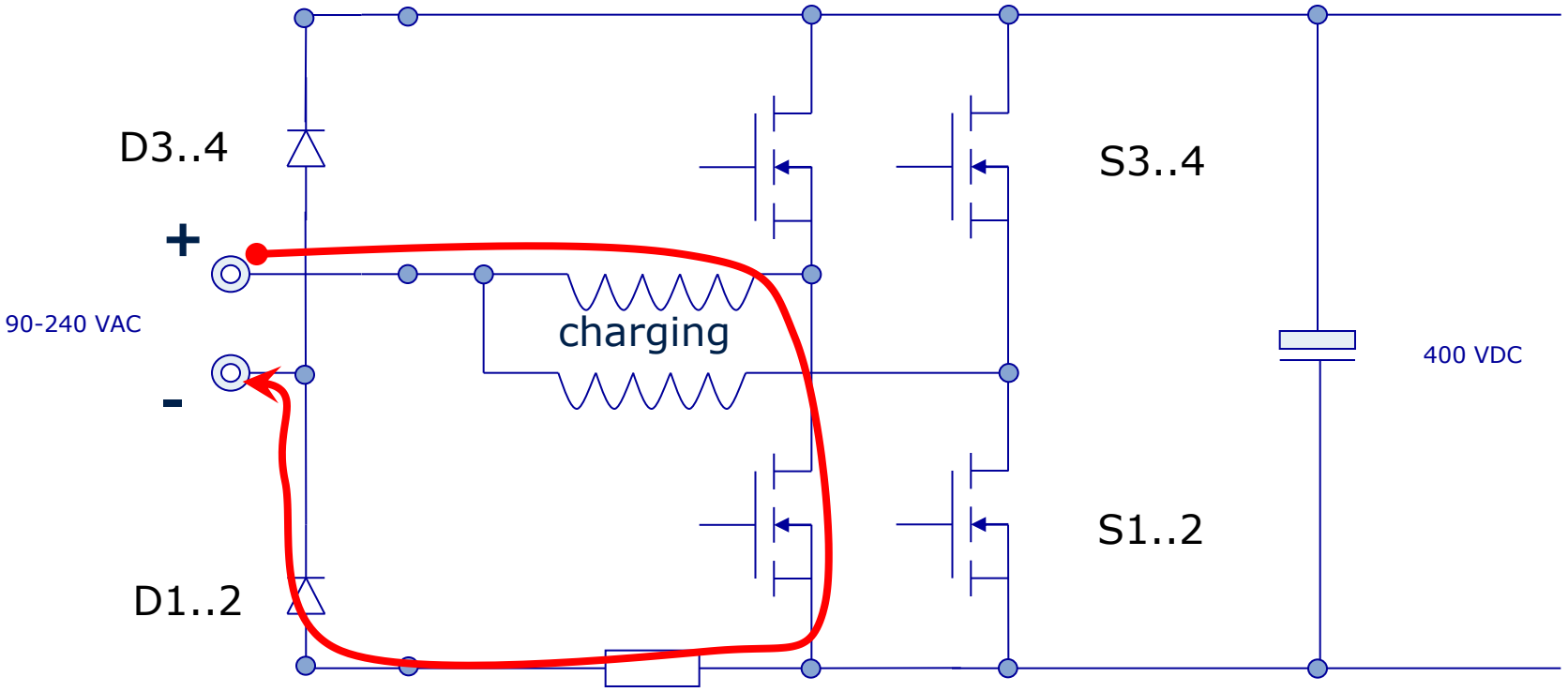


- Single Phase AC supply
- Active bridgeless PFC with wide range, Imax=16A (rms)
- Input Voltage range from 90 V to 264V (AC)
- Power Factor > 99%
- Efficiency > 94 % @ 230 VAC (> 90% @ 115V)
- galvanic isolation
- µ-controller based
- mutual supervision µC <> PLD
- ambient temperature -40 - .. +85°
- water cooling
- housing IP6k7, IP6k9k
- Volume < 4,5 litres

OBC-hardware mounted on water-cooled ground plate, picture taken in the lab

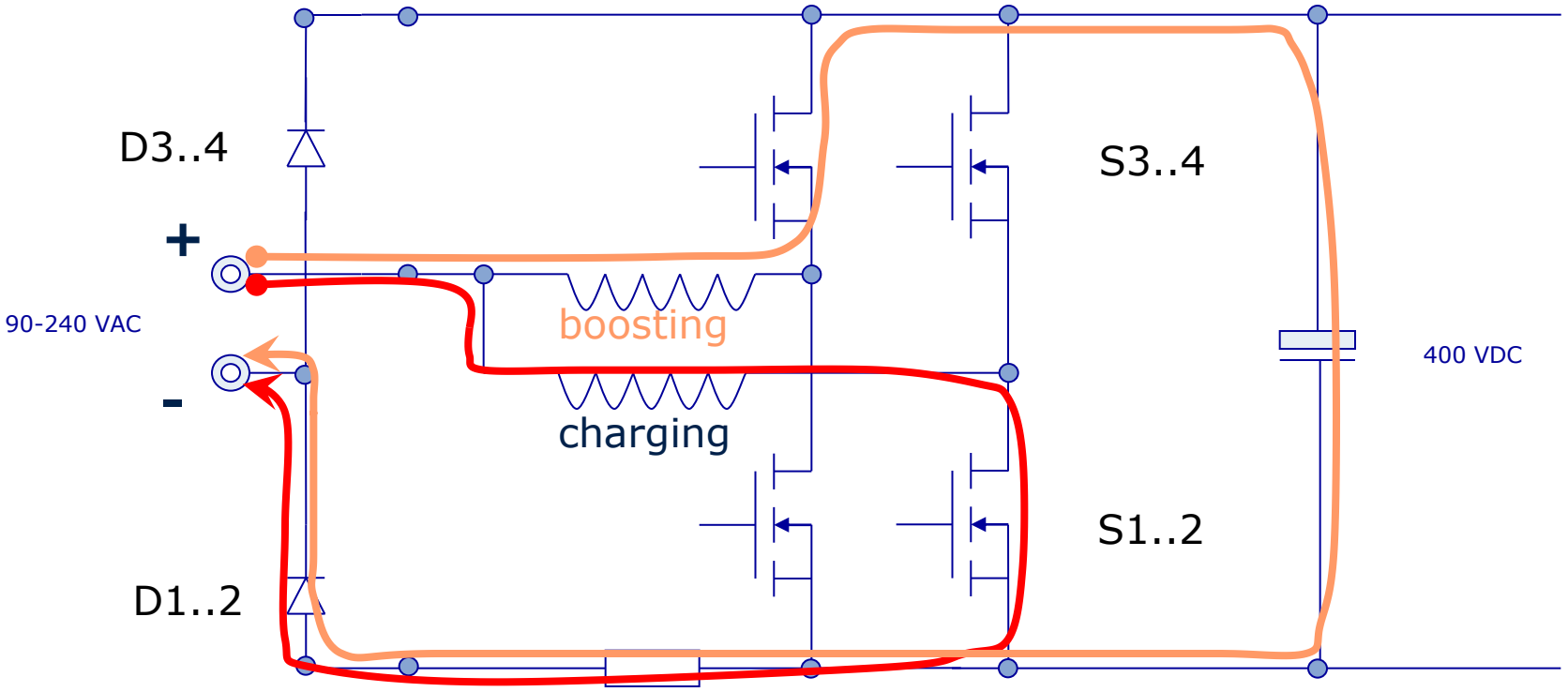


Bridgeless Resonant PFC concept : Infineon OBC solution utilizes two interleaved stages



Devices	Function	IFX part
S1..S4	Resonant PFC switches	650V CoolMOS CFDA
D1..4	Rectifier diodes	--

Bridgeless Resonant PFC concept : Infineon OBC solution utilizes two interleaved stages



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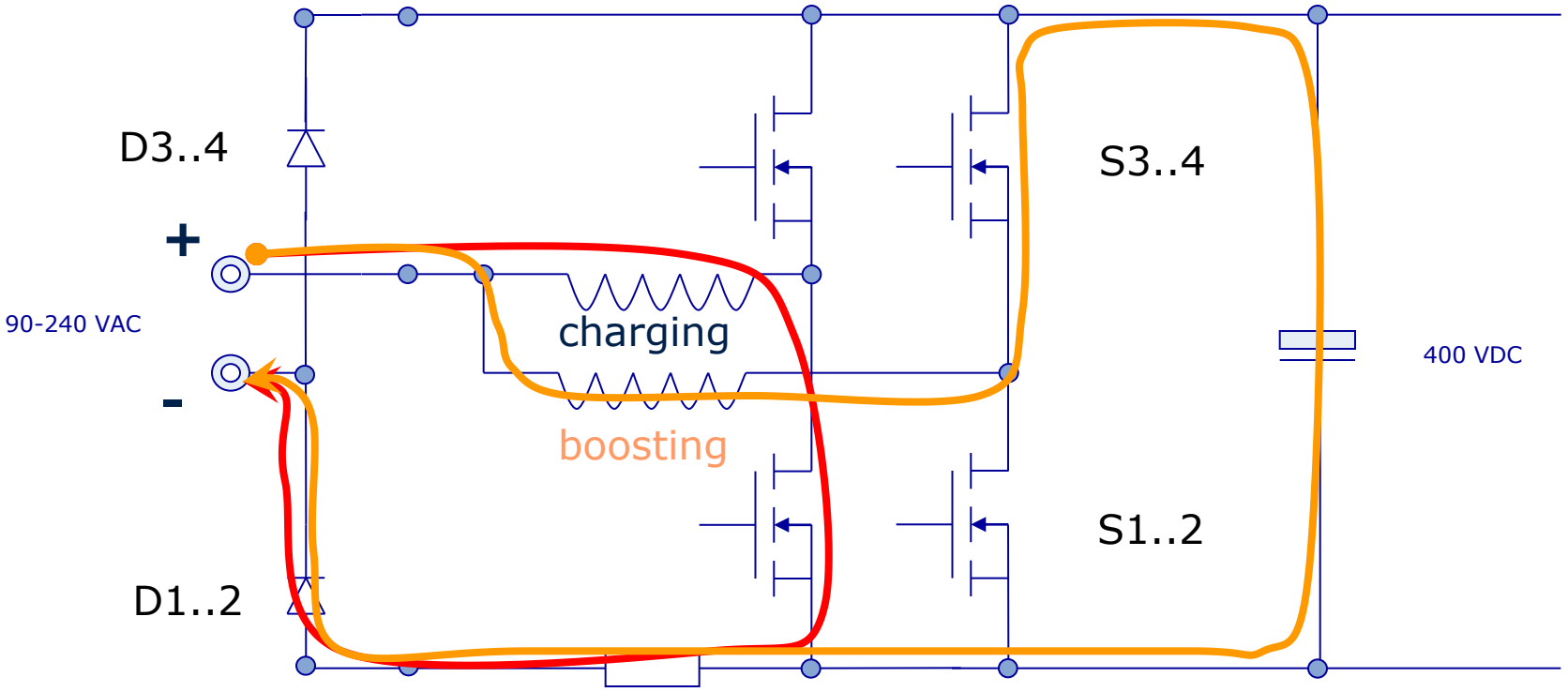
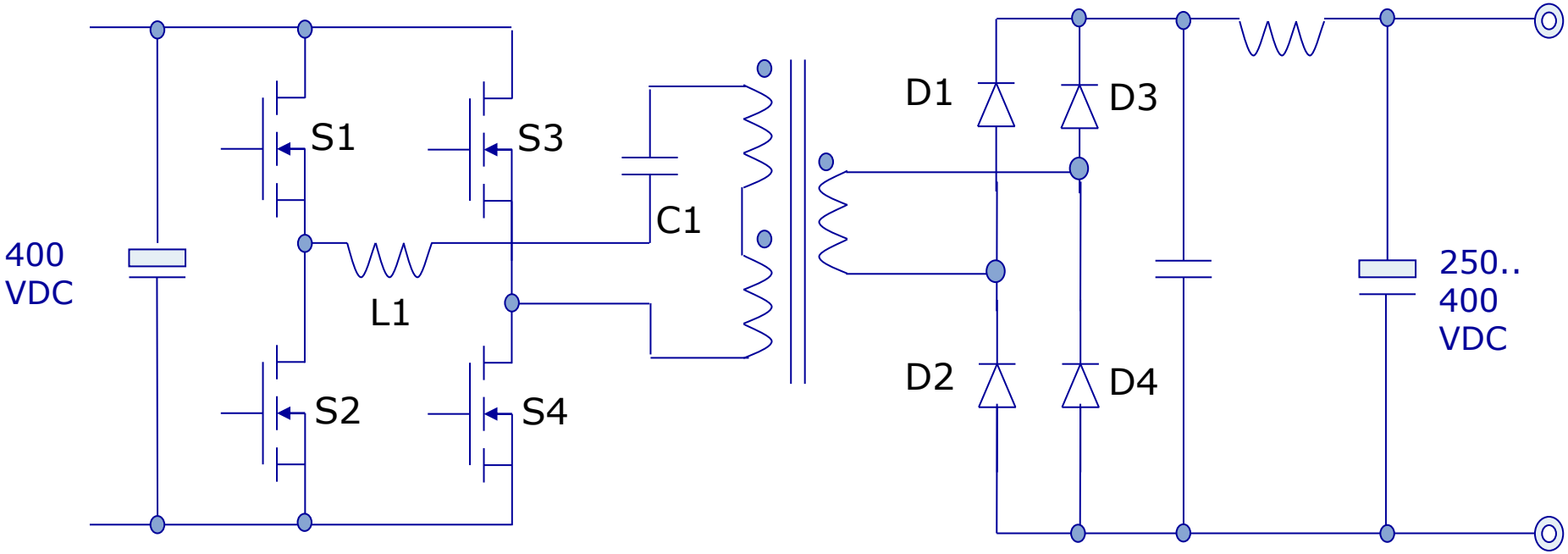
Bridgeless Resonant PFC concept : Infineon OBC solution utilizes two interleaved stages



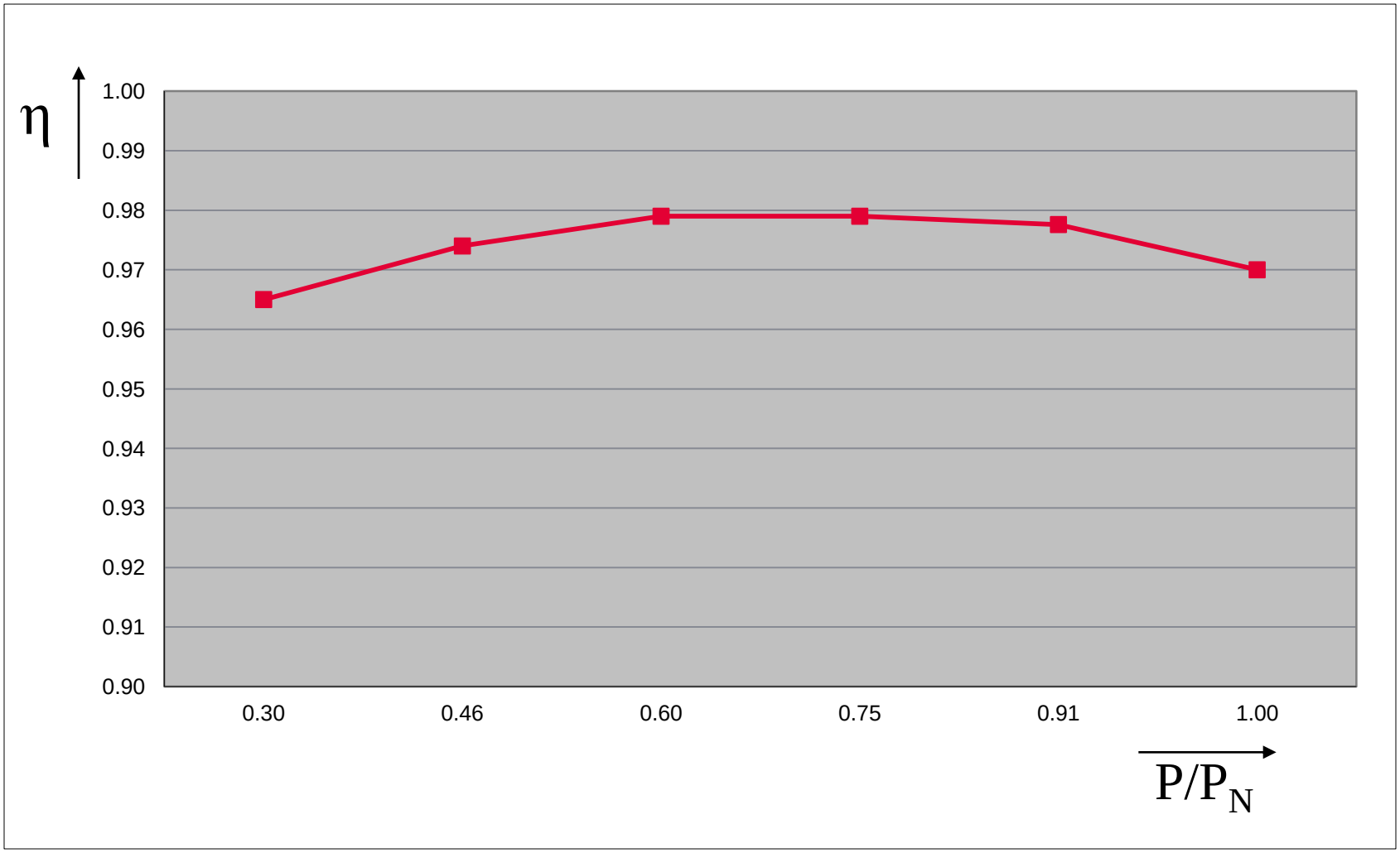
Devices	Function	IFX part
S1..S4	Resonant PFC switches	650V CoolMOS CFDA
D1..4	Rectifier diodes	--

DC/DC (LLC) converter : Infineon OBC solution implements galvanic isolation

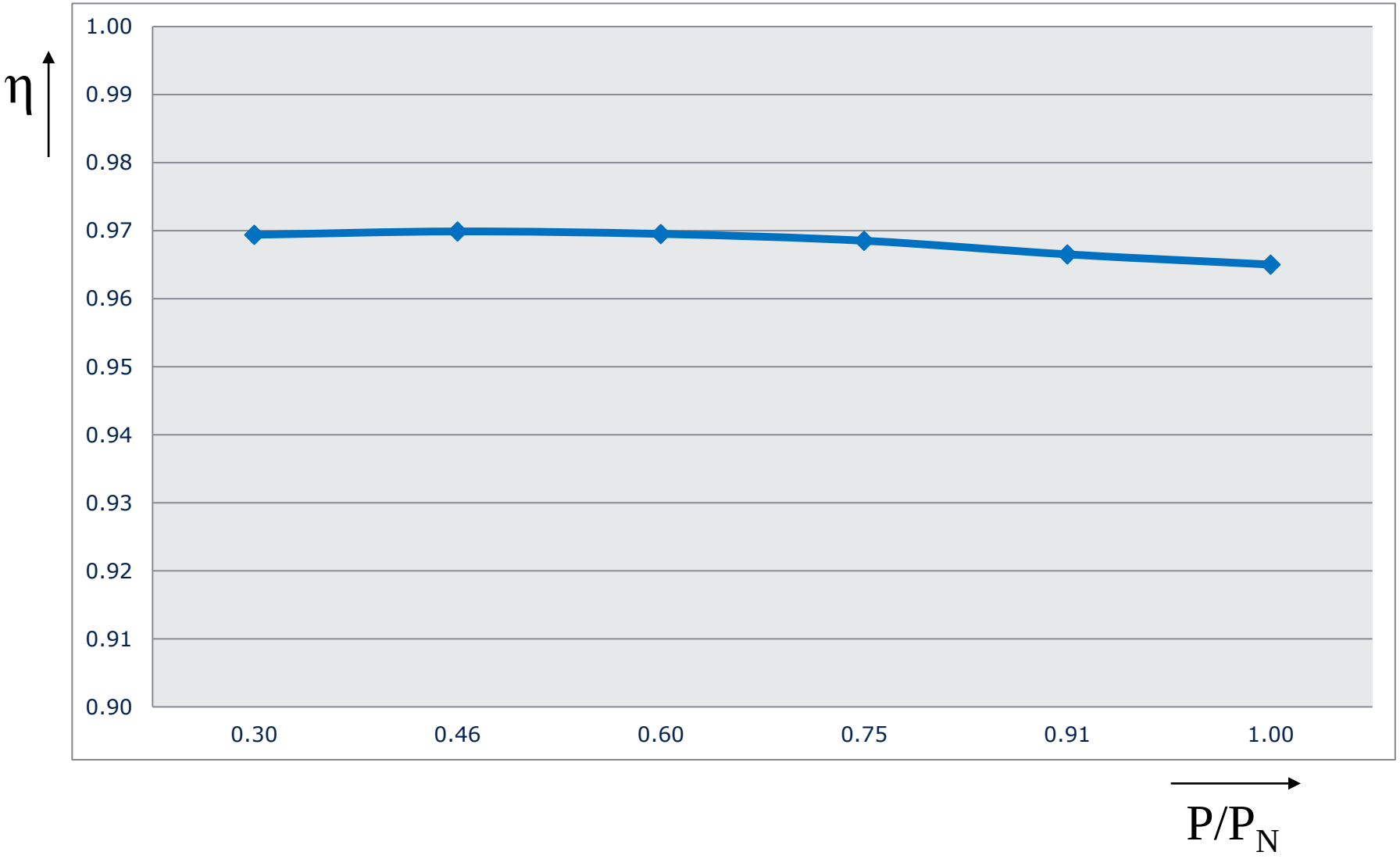


Devices	Function	IFX part
S1..S4	FB LLC switches	650V CoolMOS CFDA
D1..4	Rectifiier diodes	Diode IDP23E60

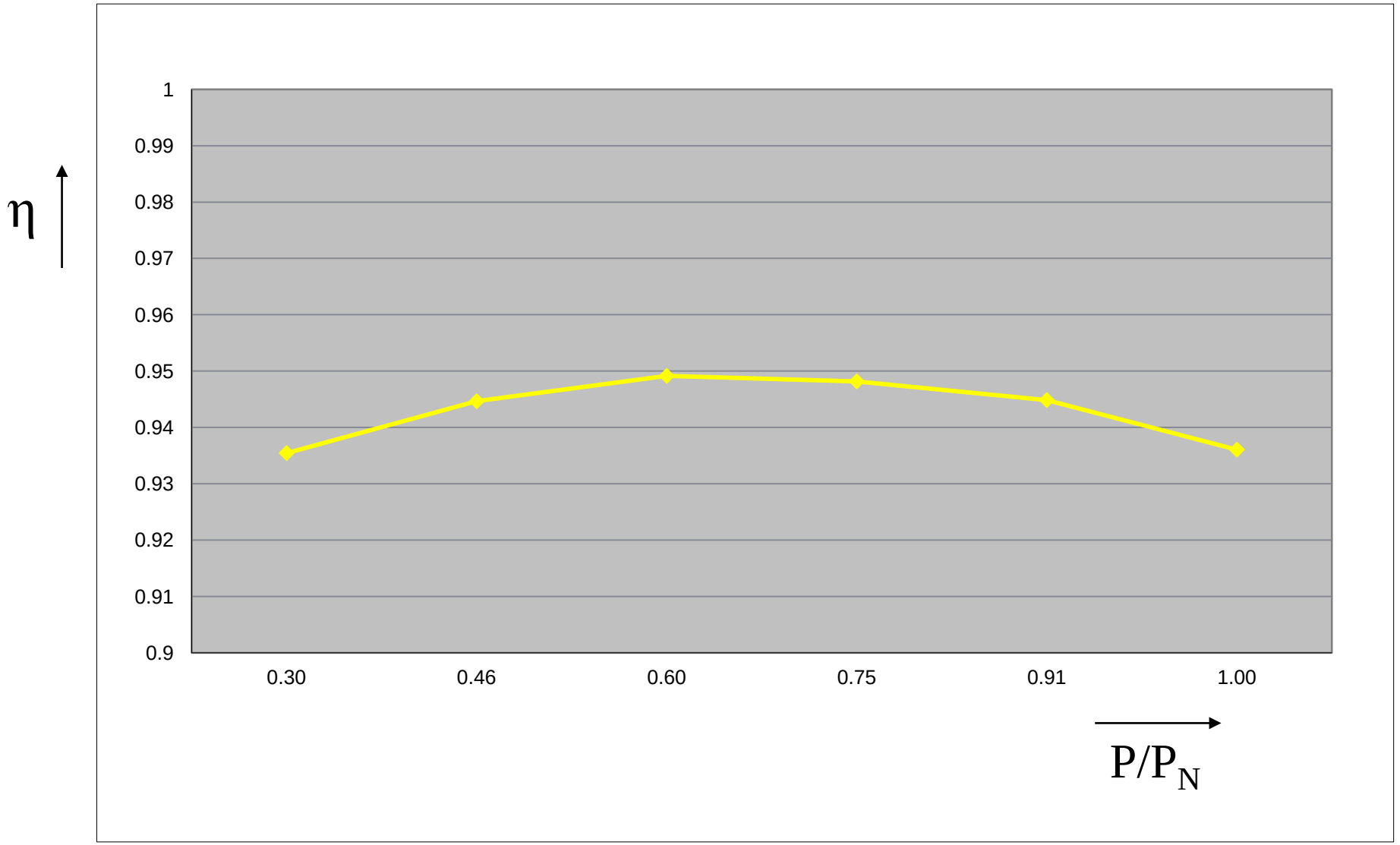
Infineon OBC solution : evaluation results, Efficiency of PFC @ 230V AC



Infineon OBC solution : evaluation results, Efficiency of LLC



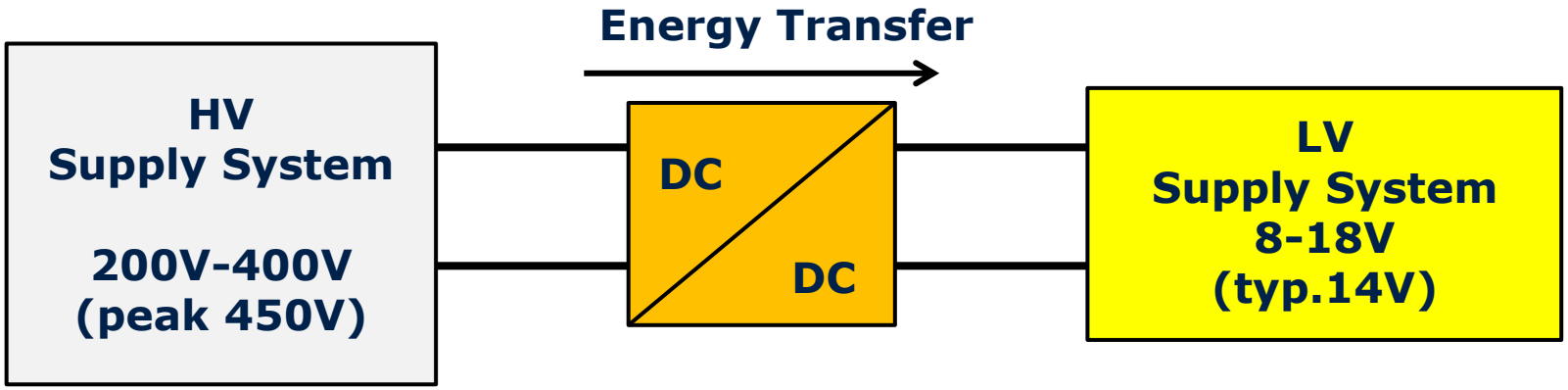
Infineon OBC solution : evaluation results, Total Efficiency



Automotive LDC(Low voltage DC/DC converter) solution

The longest market experience

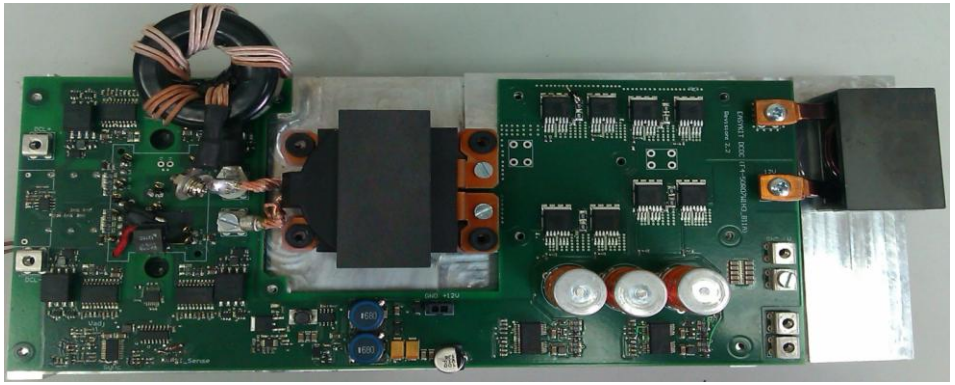
Typical requirement on DC/DC



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

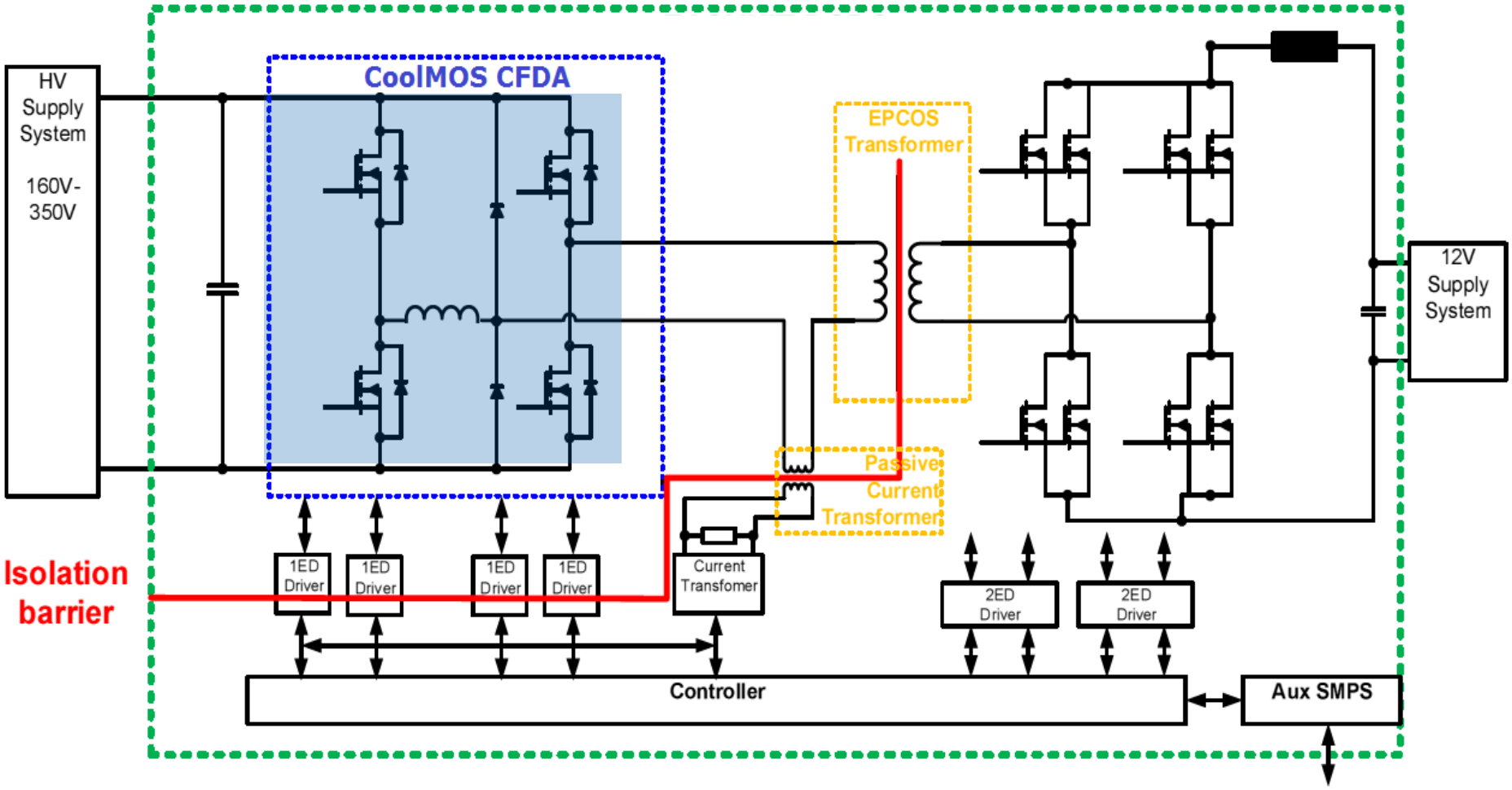
CoolMOS™ CFDA based automotive DC-DC converter - features

- Power rating: 2kW
- Input voltage: 160-300V
- Output voltage: 13.7V

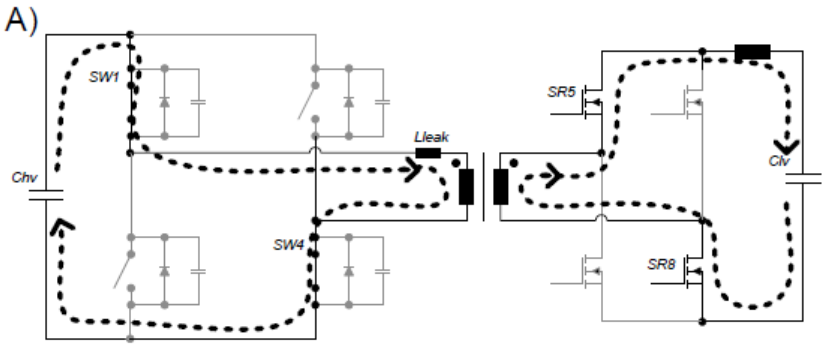


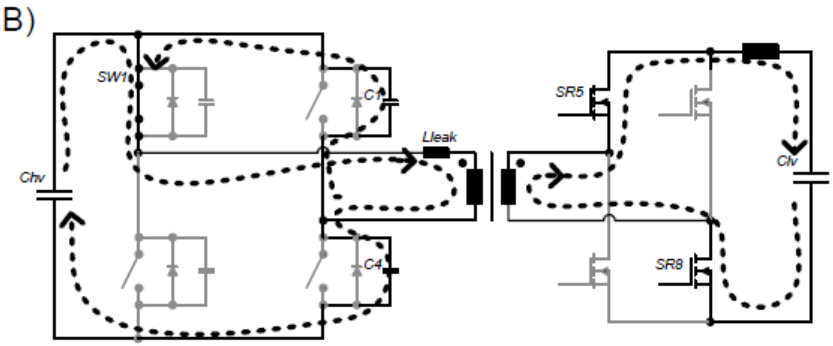
- Automotive-oriented design
- High power efficiency
- Synchronous Rectification
- High power density
- Single stage design for low cost

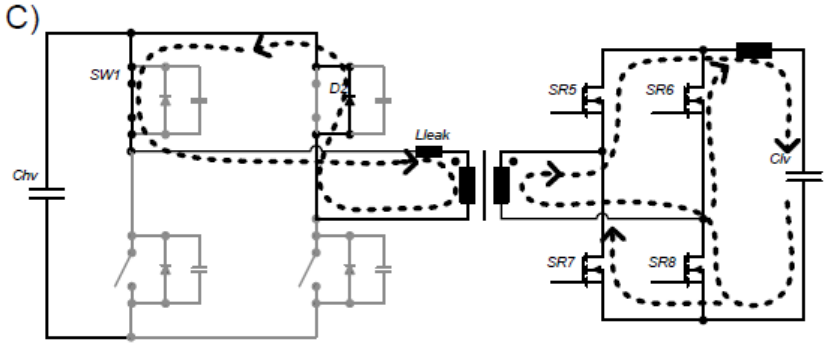
CoolMOS™ CFDA based automotive DC-DC converter - block diagram



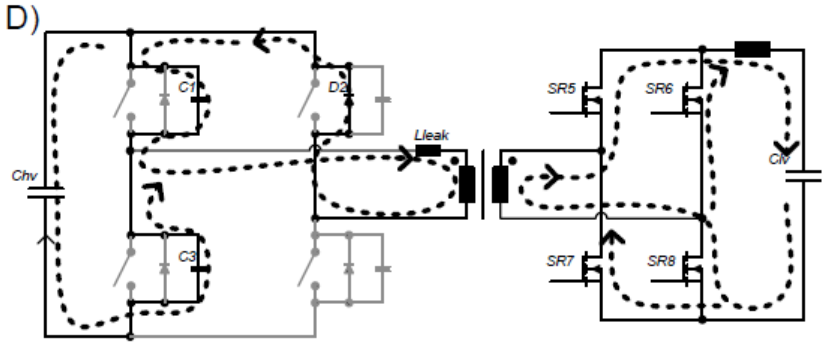
Topology
- Function principle of ZVS PSFB

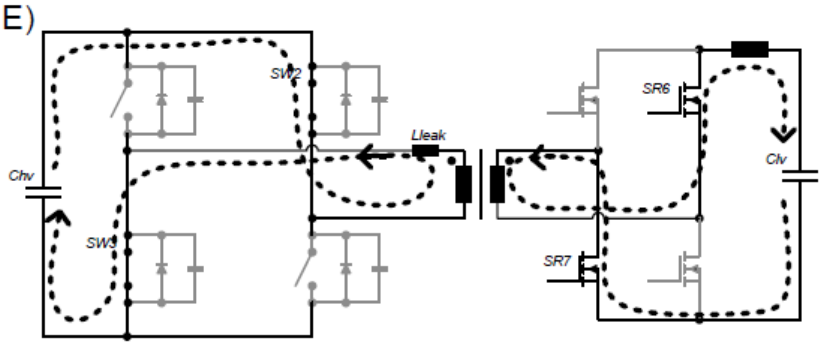




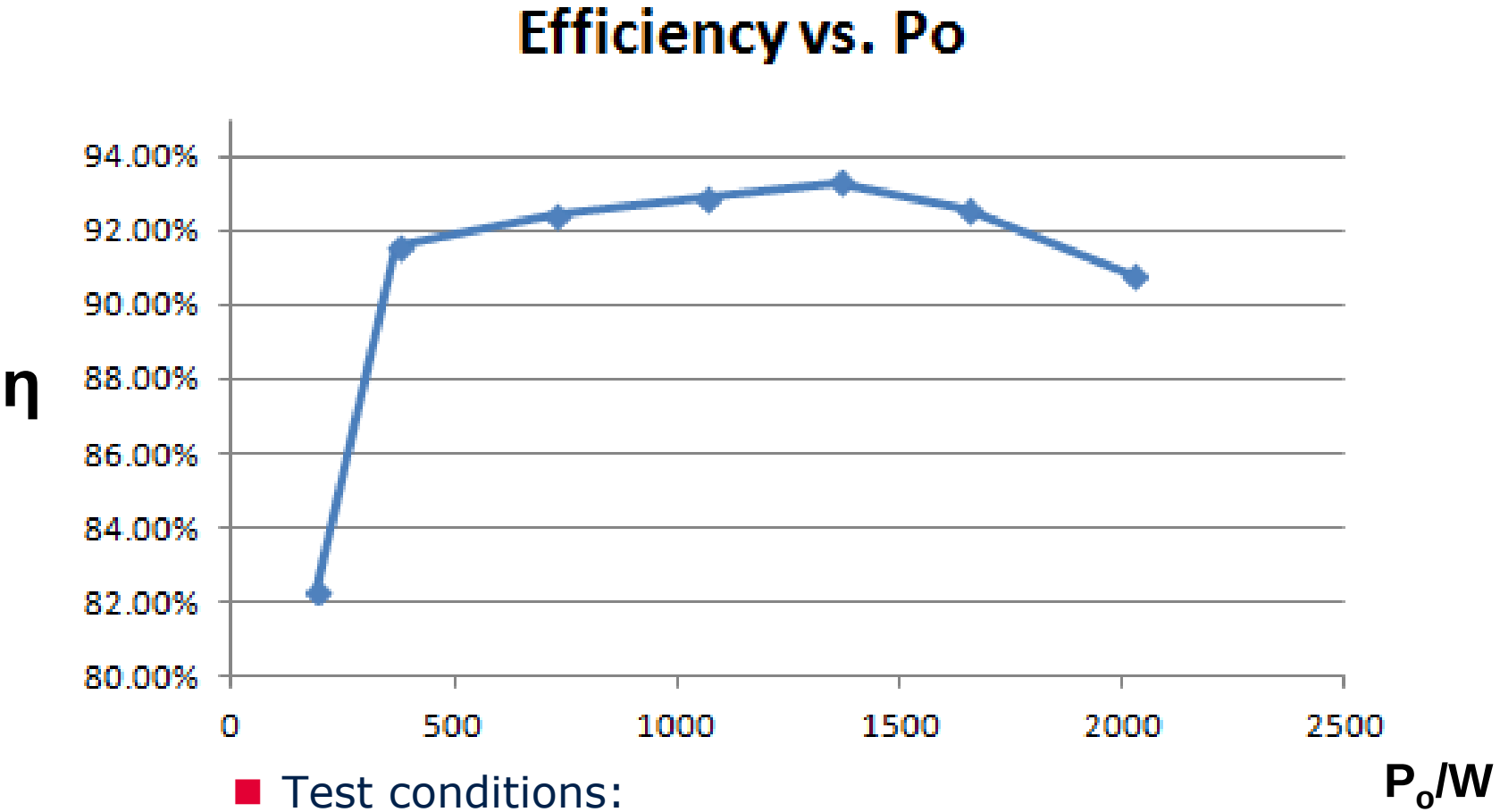


A: Energy Transfer (half cycle positive)
B: Right Leg Transition (during dead time)
C: Free Wheeling (half cycle)
D: Left Leg Transition (during dead time)
E (similar to A): Energy Transfer (half cycle negative)
F (similar to B): Right Leg Transition (during dead time)
G (similar to C): Free Wheeling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

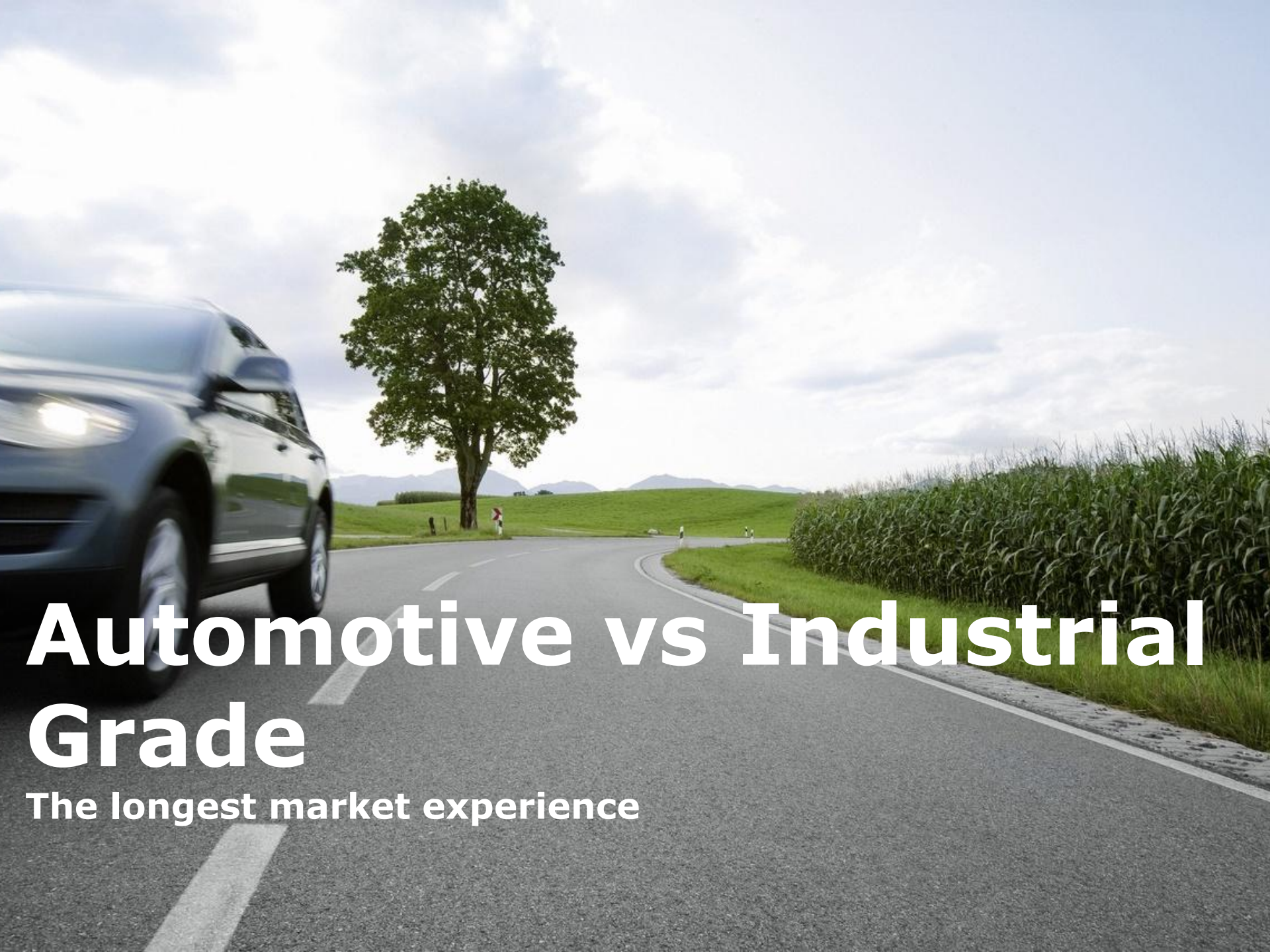




Test results
-efficiency at wide operating range



- Test conditions:
  - V_{in}=275V, V_o=13.7V, $T_{ambient}$: 27deg.c
  - P_o: from 200 to 2000W



Automotive vs Industrial Grade

The longest market experience

Quality management requirements
Qualification level

- Automotive
  - Qualification as per Automotive Electronic Council Q100/101 guideline, in terms of reliability tests, release criteria and sample size.
  - Remark: a label „Automotive AEC Q100/101 Qualified" on the corresponding product data sheet may indicate above.
  - Fulfillment of any additional bilateral agreements with automotive customers regarding qualification
  - Extended requirement deviation management and screening, change management

- Industrial
  - Qualification as per JEDEC standard guideline in terms of reliability tests, release criteria and sample sizes.
  - all applications of life time above 5 years in demanding environment and operation conditions (e.g. lightning, telecom…)

JEDEC (Joint Electron Device Engineering Council) : Solid State Technology Association
AEC (Automotive Electronics Council) : AEC-Q100(IC), AEC-Q101(discrete semiconductor), AEC-Q200(passive components)

Quality management requirements
Production point of view

	Automotive	Non-automotive
Operating temperature	-40 - 150 °C dependend on product/application	-25 - +150 °C dependend on product/application
Change management / PCN	According ZVEI customer approval required	According Jedec 46 Lack of acknowledgement of the PCN within 30 days constitutes acceptance of the change. After acknowledgement, lack of additional response within the 90 days period constitutes acceptance of the change.
Qualification	AEC-Q 100/101	Jedec

ZVEI (Zentralverband der Elektrotechnischen Industrie) : German-Central union of the Electrotechnical Industry
JEDEC (Joint Electron Device Engineering Council) : Solid State Technology Association
AEC (Automotive Electronics Council) : AEC-Q100(IC), AEC-Q101(discrete semiconductor), AEC-Q200(passive components)

Automotive CoolMOS™ CFDA

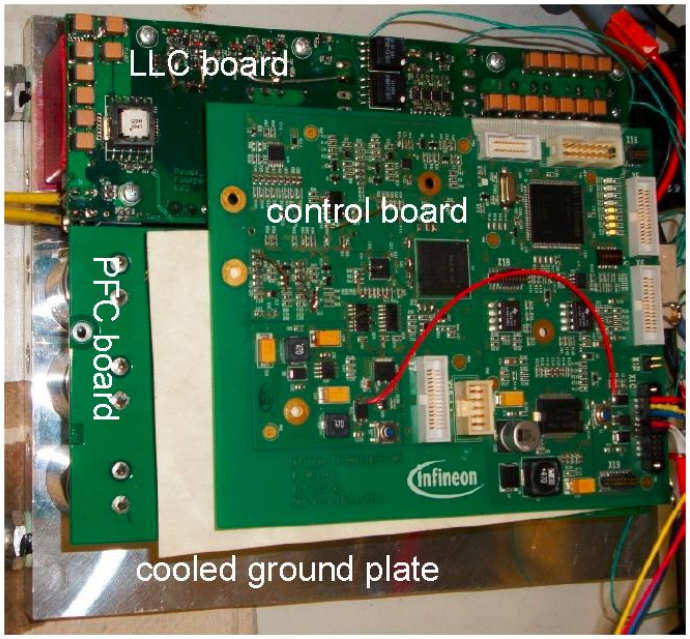
The longest market experience

CoolMOS™ GOES AUTO!

- The strong demand on high voltage MOSFETs for xEV triggered the focus of automotive applications with system solutions.

Focused applications

90Vac~
240Vac

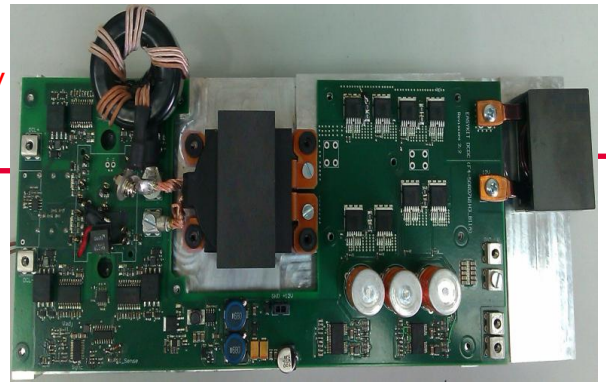


On Board Charger (OBC)

200V
~400V

Battery

160V
~300V



xEV DC/DC converter

12V

AEC Qualified

650V CoolMOS™ CFDA…

- …is the first generation of market leading **Automotive qualified** high voltage CoolMOS™ MOSFET's with **integrated fast body diode**

  *→ Suitable for a wide range of topologies (unidirectional & **bidirectional**) required in DC/DC converters & battery chargers*

- …offers a broad portfolio providing all benefits of fast switching super junction MOSFET's and fulfilling the enhanced reliability requirements for automotive applications according to **AEC Q101 standard**.
- …provides an attractive price/performance ratio

AEC Qualified

FEATURES

- 650V breakdown voltage
- Limited voltage overshoot during hard commutation - self limiting di/dt and dv/dt
- Low Qg value
- Low Qrr at repetitive commutation on body diode & low Qoss
- Reduced turn on and turn off delay times

BENEFITS

- ✓ Increased safety margin
- ✓ Reduced EMI appearance, easier to design in
- ✓ Better light load efficiency
- ✓ Lower switching losses
- ✓ Higher switching frequency and/or higher duty cycle possible

Focus Applications of CoolMOS™ CFDA

Automotive High-intensity discharge lamp

- High-intensity discharge (HID) headlamps produce light with an electric arc
- **For ignition high voltage pulse is used to produce a spark**

Piezo-injector

- Common rail diesels use piezoelectric injectors for increased precision instead of solenoid valve devices

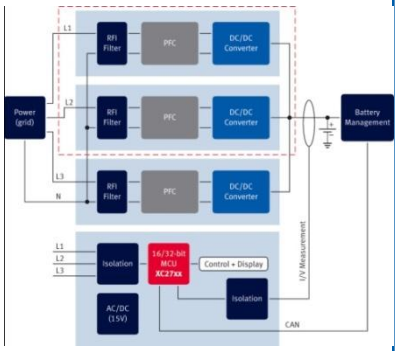
Hybrid and Electrical Vehicles

On board Charger

- With an on-board charger unit, the battery can be charged from a standard power outlet.

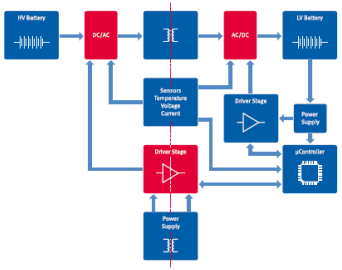
Use of CoolMOS ™ in:

- **PFC stages**
- **DC/DC stage**



HV2LV DC/DC

- in (H) EV, the DC/DC converter supplies the 12 V power system from the high-voltage battery.
- **Use of CoolMOS™ to increase conversion efficiency.**



Technical features and benefits of CFDA

Limited Voltage overshoot

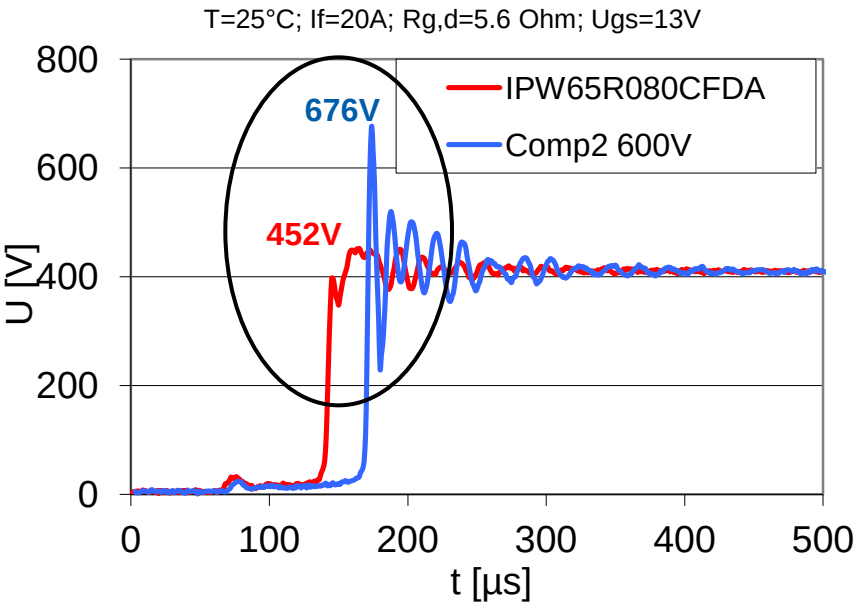
CFDA shows a limited voltage overshoot during hard commutation which contributes to **higher reliability and enables easier design in**

Softer commutation behavior

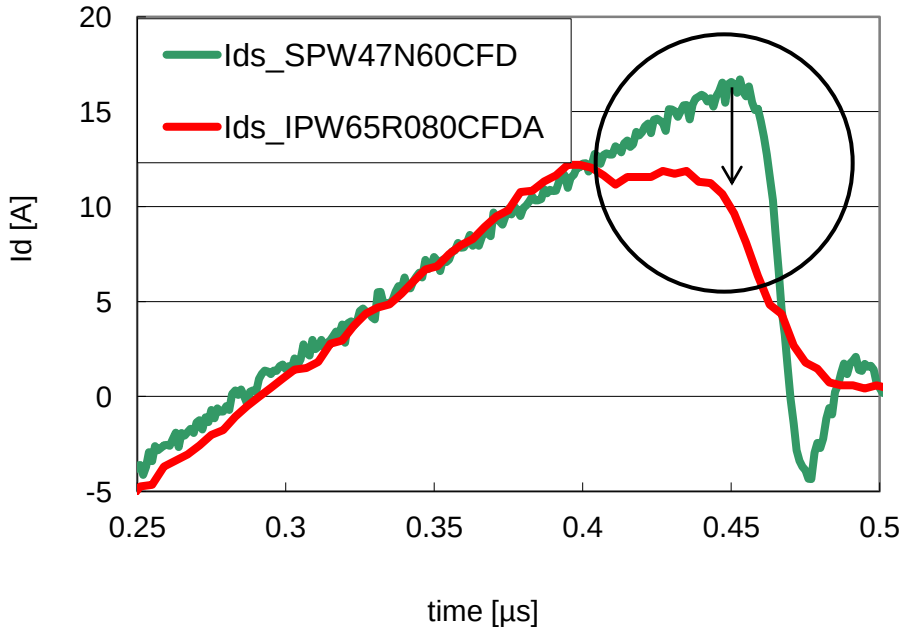
One of the main causes of EMI is the fast switching of voltage or current i.e. di/dt or dv/dt

Softer commutation of CFDA reduces risk of EMI appearance, which helps saving customers' time and money in designing in the part

Limited Voltage overshoot of CFDA



Softer commutation behavior of CFDA



CoolMOS™ CFDA Portfolio

RDS(on) [mΩ]	 DPAK	 D²Pak	 TO-220	 TO-247
660 mΩ	IPD65R660CFDA	IPB65R660CFDA	IPP65R660CFDA	
420 mΩ	IPD65R420CFDA			
310 mΩ		IPB65R310CFDA	IPP65R310CFDA	
190 mΩ		IPB65R190CFDA	IPP65R190CFDA	IPW65R190CFDA
150 mΩ		IPB65R150CFDA	IPP65R150CFDA	IPW65R150CFDA
110 mΩ		IPB65R110CFDA	IPP65R110CFDA	IPW65R110CFDA
80 mΩ				IPW65R080CFDA
48 mΩ				IPW65R048CFDA

AEC Qualified

RoHS

DC/DC

Lighting

eMobility

Launch CoolMOS™ CFDA

Official Launch Date: April, 2nd 2012

- Sending out press release
- „GO LIVE“ promopage

Promopage:

www.infineon.com/cfda

Collection of supporting material for the CFDA promotion

- Product Brief
- Press Release
- Brochure (Trifolder CFD, CFD2, CFDA)
- Application note
- Video

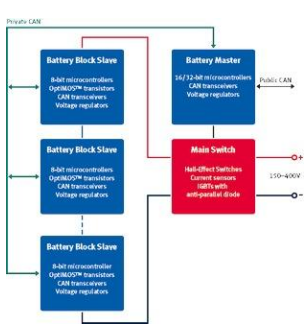
Automotive Small Signal MOSFETs

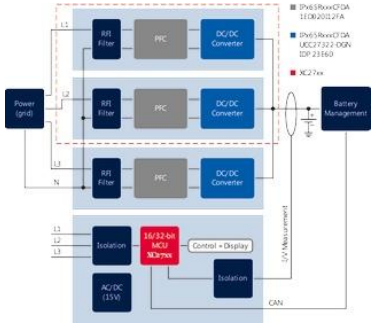
The longest market experience

Small Signal Automotive Applications

- Chassis
  - ABS
  - Traction Control
  - Electronic Stability Program
  - Electronic Brake Distribution

- Powertrain
  - HV Battery management





- Safety
  - Airbags

- Passenger comfort
  - Climate control
  - Seat adjust
  - Window/mirror adjust
  - Infotainment

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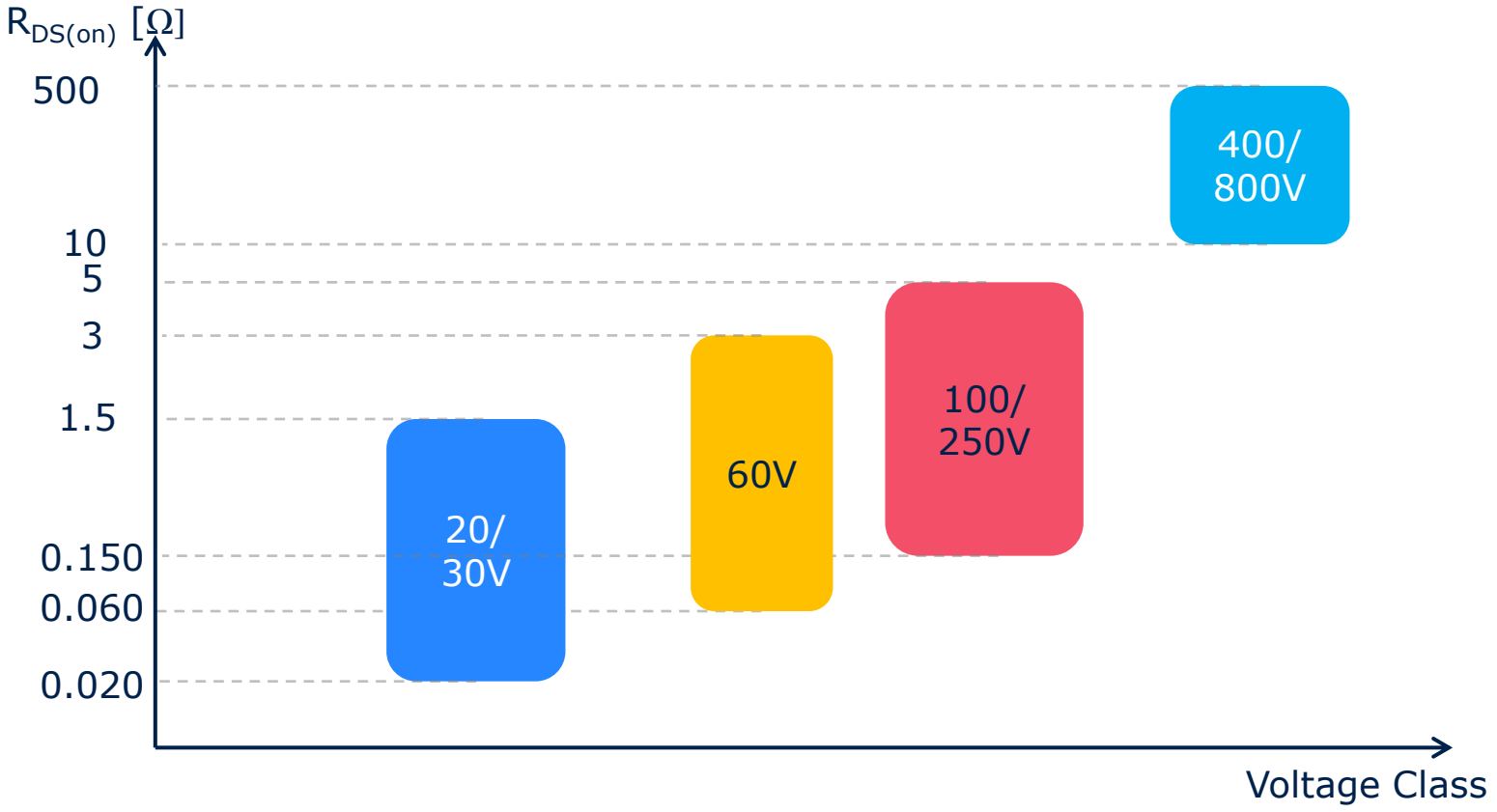
Small Signal at a Glance

Polarity	- N-Channel enhancement / N-Channel depletion - P-Channel enhancement w / and w/o ESD protection
V_{DS} range:	from -250V up to 800V
Configuration	single, dual and complementary
Gate drive voltage	1.8V (ULL), 2.5V (SLL), 4.5V (LL), 10V (NL)
Packages	SOT-223, SOT-89, TSOP-6, SC59, SOT-23, SOT-323, SOT-363 
Qualification	**AEC Q101**

Small Signal Selection Criteria

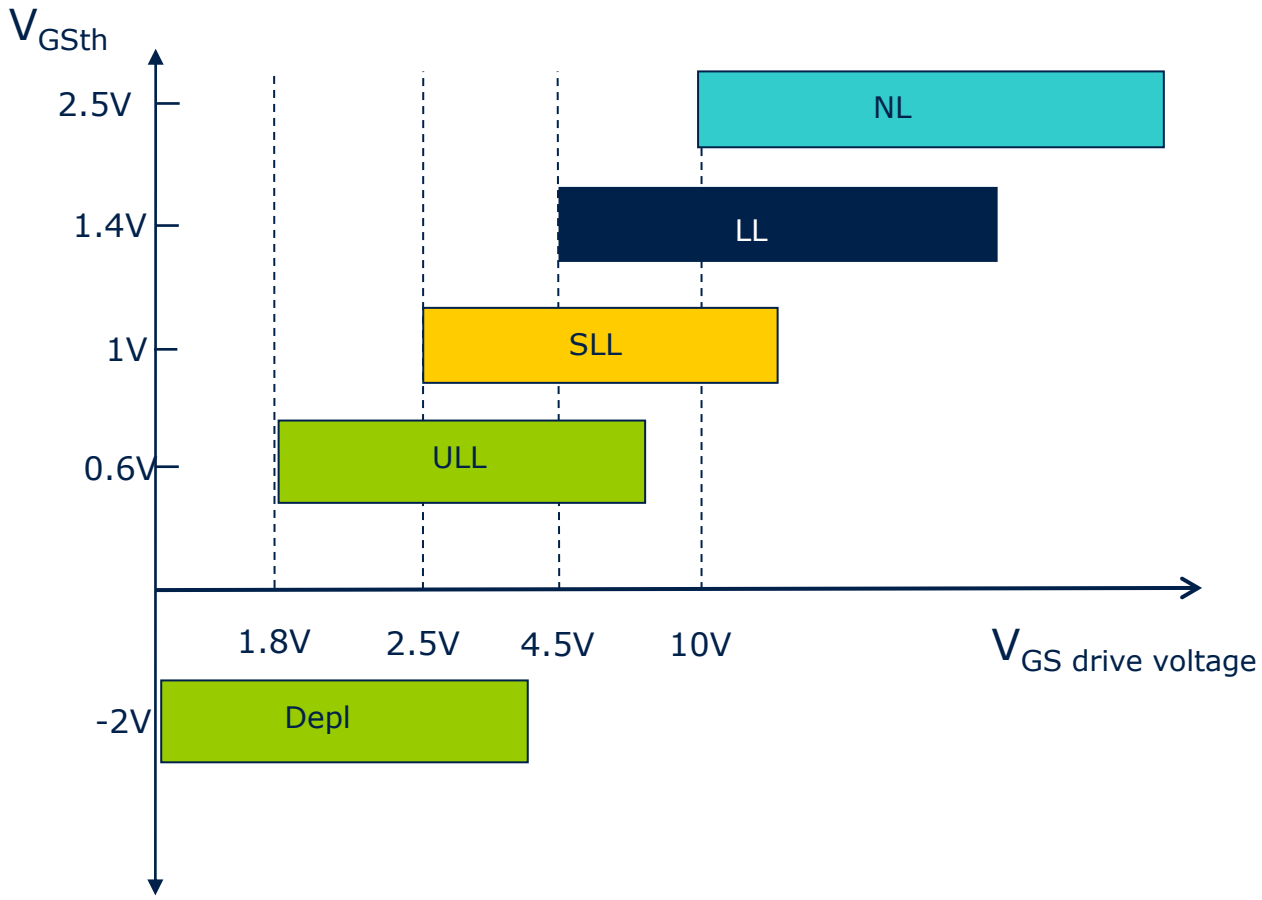
Voltage Class: -250V to 800V

$R_{DS(on)}$ max: 20mΩ to 500Ω



Small Signal Selection Criteria

V_{GS} minimum : 1.8V to 10V



Small Signal N-Channel MOSFETs < 75V

AEC Qualified

		SOT-223 	SOT-89 	TSOP-6 	SOT-23/SC59 	SOT-323 	SOT-363 
20V	20 mΩ			BSL802SN	BSR802N		
	21/22 mΩ			BSL202SN	BSR202N		
	50/60 mΩ			BSL205N (dual) BSL806N	BSS205N BSS806N		
	75 mΩ			BSL207N (dual)			
	140/160 mΩ			BSL214N (dual)	BSS214N	BSS214NW BSS816NW	BSD214SN BSD816SN
	350/400 mΩ						BSD235N (dual) BSD840N (dual)
30V	23/25 mΩ			BSL302SN	BSR302N		
	57 mΩ			BSL306N (dual)	BSS306N		
	160 mΩ				BSS316N		BSD316SN
55V	650 mΩ				BSS670S2L		
60V	60mΩ		BSS606N	BSL606SN	BSR606N		
	90 mΩ	BSP318S					
	120 mΩ	BSP320S					
	300 mΩ	BSP295					
	3 Ω				2N7002		2N7002DW (dual)
	3.5 Ω				BSS138N BSS159N	BSS138W	
	5 Ω				BSS7728N SN7002N	SN7002W	

All the products on this page are qualified according to AEC-Q101 (automotive). Exception 2N7002

Small Signal N-Channel MOSFETs ≥ 75V

		SOT-223 	SOT-89 	TSOP-6 	SOT-23/SC59 	SOT-323 	SOT-363 
75V	180 mΩ	BSP718N					
100V	300 mΩ	BSP373N (NL)					
	310 mΩ	BSP372N (LL)					
	700 mΩ	BSP296N					
	6 Ω	BSP123N			BSS123N BSS119N		
	12 Ω				BSS169		
200V	1.8 Ω	BSP297					
	3.5 Ω	BSP149					
240V	6 Ω	BSP88 (~SLL, 2.8V) BSP89 (LL) BSP129	BSS87				
	14 Ω				BSS131		
250V	30 Ω				BSS139		
400V	3 Ω	BSP298					
	25 Ω	BSP324					
500V	4 Ω	BSP299					
600V	45 Ω	BSP125	BSS225				
	60 Ω	BSP135					
	500 Ω				BSS127		
800V	20 Ω	BSP300					

All the products on this page are qualified according to AEC-Q101 (automotive).

N-Channel Depletion MOSFETs

	SOT-23 	SOT-223 
3.5 Ω (200V)		**BSP149**
6 Ω (240V)		**BSP129**
8 Ω (60V)	**BSS159N**	
12 Ω (100V)	**BSS169**	
30 Ω (240V)	**BSS139**	
60 Ω (600V)		**BSP135**
700 Ω (600V)	**BSS126**	

All depletion MOSFETs are available with limited $V_{GS(th)}$ spread, the $V_{GS(th)}$ class is indicated on the reel

All the products on this page are qualified according to AEC-Q101 (automotive).

www.infineon.com/depletion

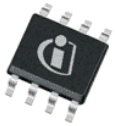
P-Channel MOSFETs

		SOT-223 	SOT-89 	SOT-23 	SC59 	SOT-323 	SOT-363 	TSOP-6 
-20V	41 mΩ							BSL207SP
	67 mΩ							BSL211SP
	150 mΩ			BSS215P				BSL215P (dual)
	175 mΩ						BSV236SP	
	550 mΩ					BSS209PW		
	1.2 Ω					BSS223PW	BSD223P (dual)	
-30V	~30 mΩ				BSR303PE			BSL303SPE
	~40 mΩ							BSL307SP
	~50 mΩ				BSR305PE			BSL305SPE
	80 mΩ			BSS308PE				BSL308PE
	140 mΩ			BSS314PE			BSD314SPE	BSL314PE
	150 mΩ			BSS315P				BSL315P (dual)
	~700 mΩ					BSS356PWE	BSD356PE	
-60V	130 mΩ	BSP613P						
	300 mΩ	BSP170P (NL) BSP171P (LL)						
	800 mΩ	BSP315P			BSR315P			
	2 Ω			BSS83P				
	8 Ω			BSS84P		BSS84PW		
-100V	1 Ω	BSP321P (NL) BSP322P (LL)						
	1.8 Ω	BSP316P			BSR316P			
-250V	4 Ω	BSP317P						
	12 Ω	BSP92P	BSS192P		BSR92P			

All the products on this page are qualified according to AEC-Q101 (automotive).

Grey: Q4 2014

Complementary MOSFETs

		SO-8 	TSOP6 	SOT-363 
-20V / 20V	150 mΩ (N-Ch) 150 mΩ (P-Ch)		BSL215C	
	0.55 Ω (N-Ch) 1.1 Ω (P-Ch)			BSD235C
-30V / 30V	160 mΩ (N-Ch) 150 mΩ (P-Ch)		BSL316C	
	~60 mΩ (N-Ch) 80 mΩ (P-Ch)		BSL308C	
	~300 mΩ (N-Ch) ~560 mΩ (P-Ch)			BSD356C
-60V / 60V	110 mΩ (N-Ch) 300 mΩ (P-Ch)	BSO615C G		
	120 mΩ (N-Ch) 300 mΩ (P-Ch)	BSO612CV G		

All the products on this page are qualified according to AEC-Q101 (Automotive).

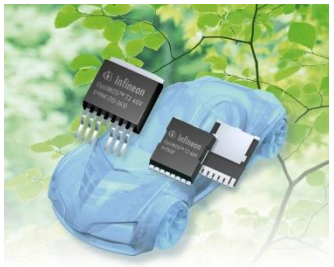
Grey: Q4 2014

www.infineon.com/complementary

Small Signal MOSFET

Promopage: Products link page

www.infineon.com/mosfet



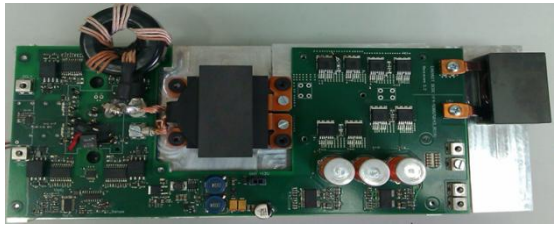
AEC Qualified

Collection of supporting material for the small signal MOSFET promotion

- Product Brief
- Press Release
- Brochure
- Application note
- Video

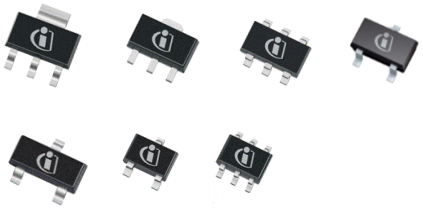
Summary

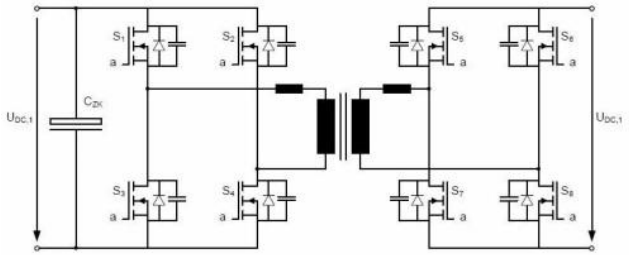
- Infineon is a **system solution provider** for xEV application with **OBC and automotive DCDC converter**.



AEC Qualified

- Infineon provided **650V CoolMOS™ and Small Signal MOSFET** for this high efficiency solution. **Automotive qualified CoolMOS™ CFDA with fast body diode** brings both high efficiency and high reliability to a wide range of topologies, like **ZVS-PSFB resonant topologies.**





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