Next Generation CoolMOS™ based solutions for EV Charging

Oct, 2020

Agenda

1. EV charging market overview
2. CoolMOS™ 7 series for EV charging applications
3. Infineon's further product offering for EV charging

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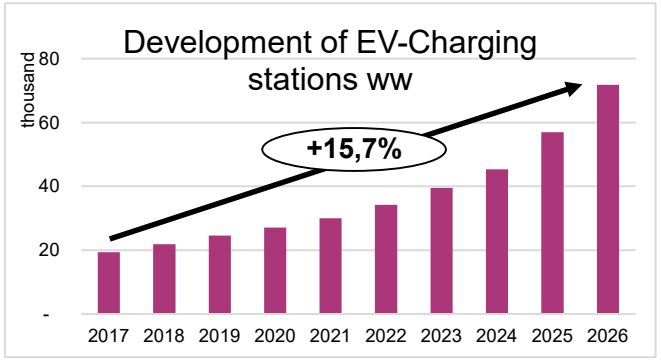
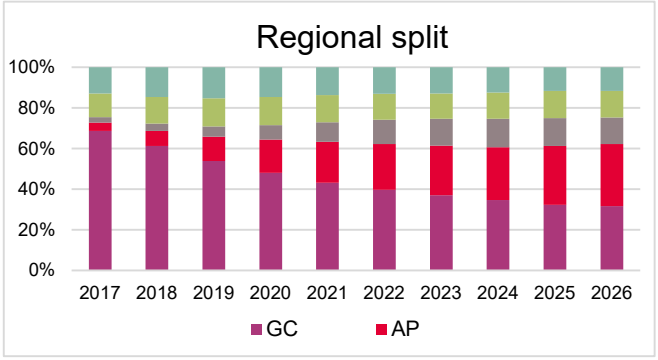
EV charging station market and main drivers

The need for electrification and therefore a sufficient charging infrastructure is given due to…

- Increased health problems and high air pollution
- Government regulations on CO_2 emissions
- Governmental subsidies and increased demand for electric vehicles





Source: Navigant Research, Q2 2017

EV charging station market is **a growing segment**

EV charging station market trends

Faster charging thanks to **higher output power**

- Three phase 15 kW → 20 and 30 kW per module
- Output power to increase further especially in EMEA and US market but also in GC and AP

Size reduction of EV charging stations („form factor")

- Higher power at given size of charging station → increase of power density
- Increase of switching frequency → reduction of passive components (e.g. transformer)

Increasing efficiency trends towards 95%

- 93% at full load move to 95% and beyond
- Less power/heat dissipation
  - Improved reliability
  - Extended lifetime (e.g. e-cap's)
  - Reduced heatsink (power density & size)

Reduction of cost per watt

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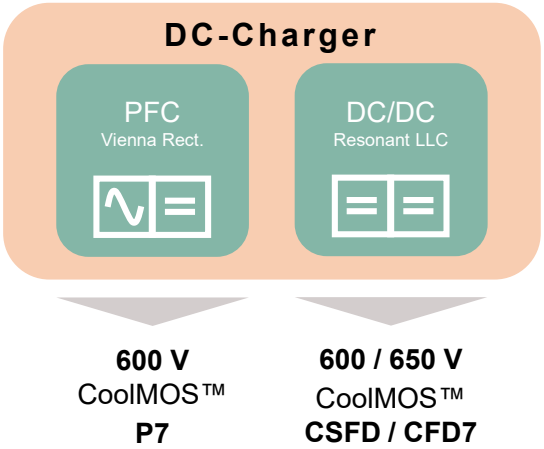
CoolMOS™ 7 to address EV charging market

Block diagram of a typical DC-Charger



600 V CoolMOS™ P7 to address the PFC stage in EV charging applications

600 V CoolMOS™ P7	600 / 650 V CoolMOS™ CSFD/CFD7
Suitable for **PFC and LLC topologies**	Suitable for **LLC and PS FB ZVS topologies**
Recommended for usage in **PFC stage in EV Charging**	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

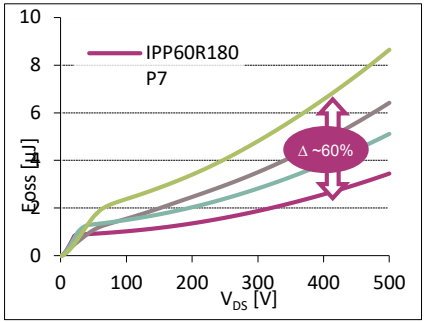
+ Adapter, Lighting, Industrial SMPS, TV, Solar, PC Power, Server, Telecom, EV-Charging

- **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

+ Server, Telecom, EV-Charging

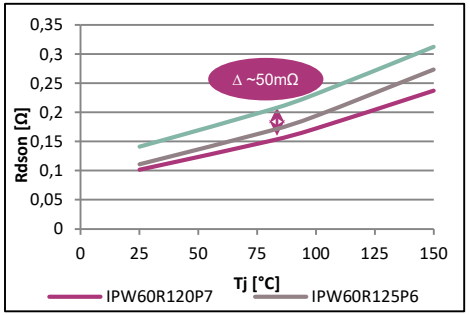
CoolMOS™ 600 V P7 – Technological highlights

Best-in-Class E_{oss}



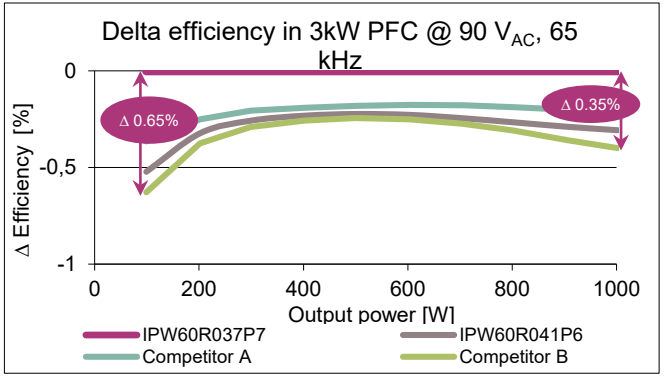
- Up to 60 % lower Eoss compared to main competition
- Reduced switching losses leading to higher light load efficiency

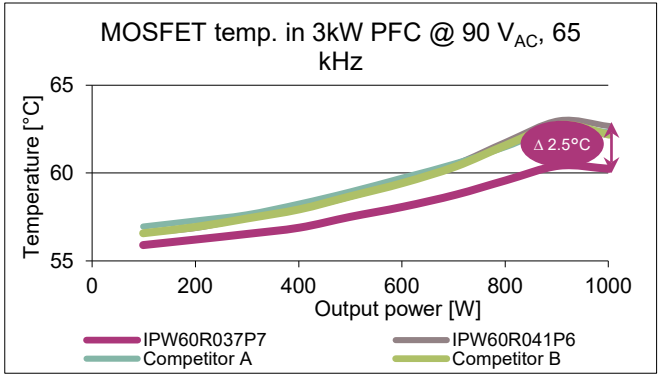
Best-in-Class $R_{DS(on)}$ dependency over T_j



- CoolMOS™ P7 lower $R_{DS(on)}$ increase with increasing junction temperature
- Reduced conduction losses leading to improved full load efficiency

Improved Efficiency and thermals compared to main competition





600 V CoolMOS™ P7 – Product portfolio

600 V CoolMOS P7 SJ MOSFETs

	$R_{DS(on)}$ [mΩ]	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		IPAN60R180P7S	IPAW60R180P7S			

ESD ruggedness: HBM class 2 (>2kV)

Infineon's recommendation for EV-Charging

600 V CoolMOS™ CSFD/CFD7 to address the DC/DC stage in EV charging applications

600 V CoolMOS™ P7

Suitable for

PFC and LLC topologies

Recommended for usage in

PFC stage in EV Charging

600 / 650 V CoolMOS™ CSFD/CFD7

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

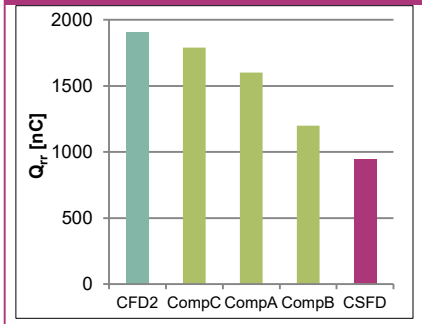
+

- **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 Rdson in THD and SMD packages
- IPW60R037CSFD as optimized replacement for IPW65R041CFD

+

CoolMOS™ 600 / 650 V CFD7/CSFD – Technological highlights

Best-in-Class Q_{rr}

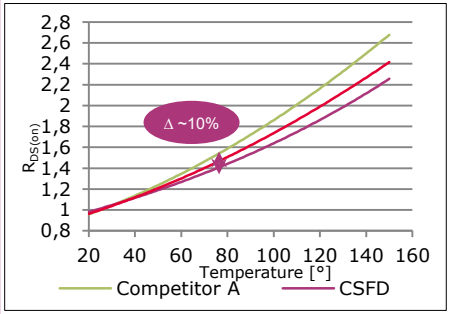


CoolMOS™ CSFD secures an outstanding Q_{rr} level, even at a lower $R_{DS(on)}$

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

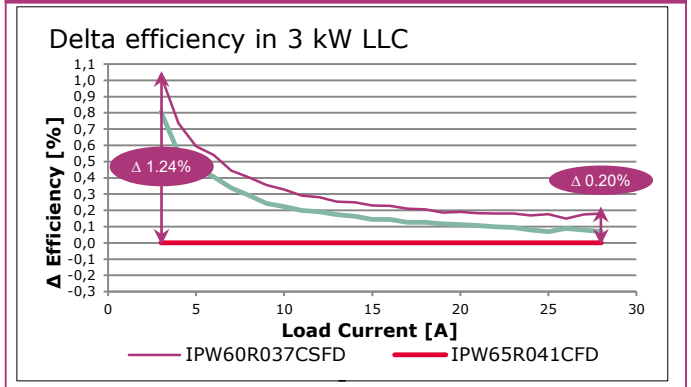
CoolMOS™ CSFD bring benefit in $R_{DS(on)}$ without loosing in Q_{rr}

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

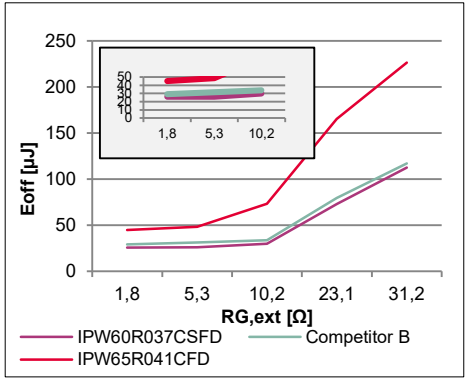


- CoolMOS™ P7 lower $R_{DS(on)}$ increase with increasing junction temperature
- Reduced conduction losses leading to improved full load efficiency

Improved Efficiency over competition



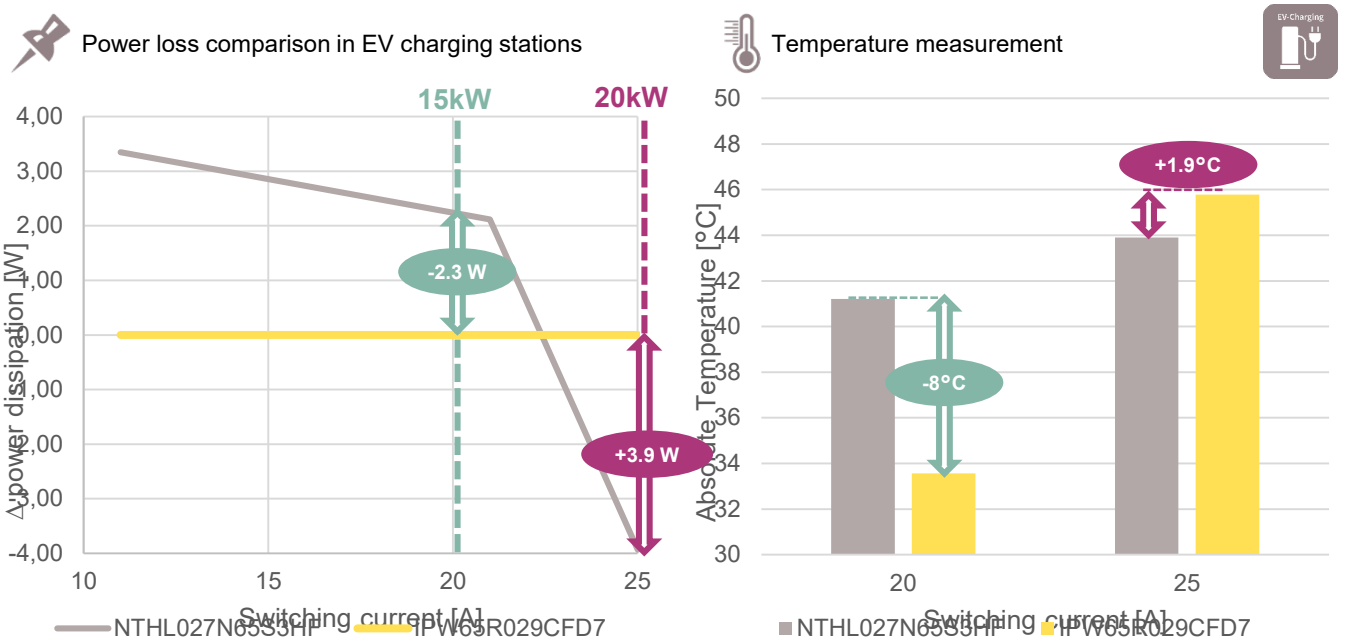
Improved turn-off behavior to improve oscillation tendency



CoolMOS™ CSFD

- 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

650 V CoolMOS™ CFD7 in 15 and 20 kW EV charging station designs

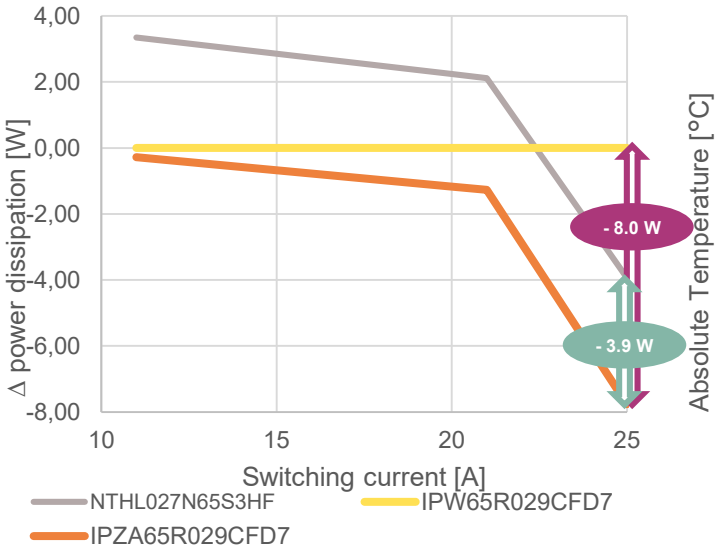


- 650 V CoolMOS CFD7 offers **2.3 W lower total losses** and **8 ° C lower temperature** in 15 kW EV charging station setup
- In 20 kW EV-charging station designs, the 650 V CoolMOS CFD7 products show higher total losses but **still competitive thermals**

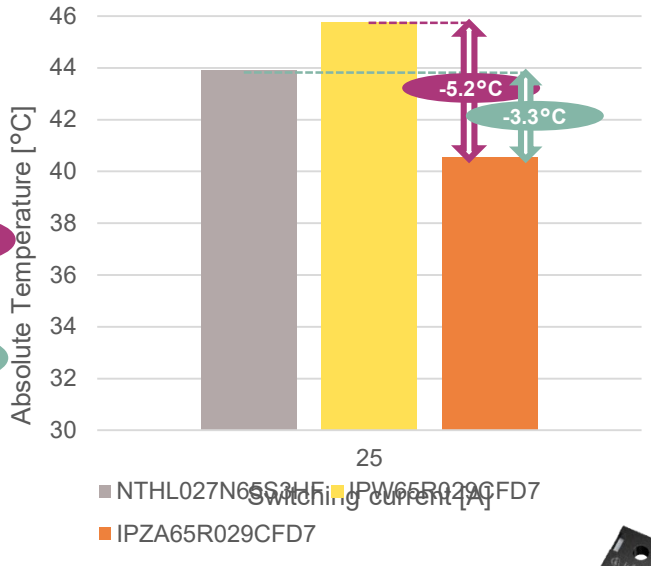
Measurement done in Infineon internal test platform

650 V CoolMOS™ CFD7 performance in 20 kW EV charging taking advantage of using 4 pin package

Power loss comparison in EV charging stations



Temperature measurement



At higher current operation 650 V CoolMOS™ CFD7 in TO247-4 pin package offers:

- **3.9 W lower total losses** and **3.3 °C improved thermals** over competiton
- up to **8 W lower total losses** and additional **5.2 °C better thermals** compared to the TO247-3pin package

Measurement done in Infineon internal test platform

600 V CoolMOS™ CFD7 / CSFD – Product portfolio

600 V CoolMOS™ CFD7 SJ MOSFETs

$R_{DS(ON)}$ [mΩ]	 TO-263 D²PAK	 TO-252 D-PAK	 ThinPAK 8x8*	 TO-220	 TO-220 FullPAK	 TO-247	 TOLL	 DDPAK	 QDPAK
360	IPB60R360CFD7	IPD60R360CFD7		IPP60R360CFD7	IPA60R360CFD7				
280	IPB60R280CFD7	IPD60R280CFD7		IPP60R280CFD7	IPA60R280CFD7				
210/215	IPB60R210CFD7	IPD60R210CFD7	IPL60R225CFD7	IPP60R210CFD7	IPA60R210CFD7				
170/185	IPB60R170CFD7	IPD60R170CFD7	IPL60R185CFD7	IPP60R170CFD7	IPA60R170CFD7	IPW60R170CFD7		IPDD60R170CFD7	
145/160	IPB60R145CFD7	IPD60R145CFD7	IPL60R160CFD7	IPP60R145CFD7	IPA60R145CFD7	IPW60R145CFD7	IPT60R145CFD7	IPDD60R145CFD7	
125/140	IPB60R125CFD7		IPL60R140CFD7	IPP60R125CFD7	IPA60R125CFD7	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
37						IPW60R037CSFD			
31/35						IPW60R031CFD7	IPT60R035CFD7		IPDQ60R035CFD7
24/25						IPW60R024CFD7			IPDQ60R025CFD7
18/20						IPW60R018CFD7			IPDQ60R020CFD7
15									IPDQ60R015CFD7

Infineon's recommendation for EV-Charging

Mid 2021

tbd

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

650 V CoolMOS™ CFD7 SJ MOSFETs

$R_{DS(ON)}$ [mΩ]	TO-220	TO-247	TO247-4	TO-263 D²PAK	ThinPAK 8x8	TOLL	QDPAK
190/195	IPP65R190CFD7				IPL65R195CFD7	IPT65R190CFD7	
155/160	IPP65R155CFD7	IPW65R155CFD7		IPB65R155CFD7	IPL65R160CFD7	IPT65R155CFD7	
125/130		IPW65R125CFD7		IPB65R125CFD7	IPL65R130CFD7	IPT65R125CFD7	IPDQ65R125CFD7
110/115	IPP65R110CFD7	IPW65R110CFD7		IPB65R110CFD7	IPL65R115CFD7		
90/95/99	IPP65R090CFD7	IPW65R090CFD7		IPB65R090CFD7	IPL65R095CFD7	IPT65R099CFD7	IPDQ65R099CFD7
80						IPT65R080CFD7	IPDQ65R080CFD7
60/65	IPP65R060CFD7	IPW65R060CFD7			IPL65R065CFD7	IPT65R060CFD7	IPDQ65R060CFD7
40 / 41	IPP65R041CFD7	IPW65R041CFD7		IPB65R041CFD7		IPT65R040CFD7	IPDQ65R040CFD7
29		IPW65R029CFD7	IPZA65R029CFD7				IPDQ65R029CFD7
17 / 18		IPW65R018CFD7	IPZA65R018CFD7				IPDQ65R017CFD7

Telecom

Server

EV-Charging

Solar

Infineon's recommendation for EV-Charging

Begin 2021

tbd

Solution to address soft-switching applications in high power SMPS

Summary: CoolMOS™ 7 for EV charging applications 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)
  - Reduced conduction losses and improved thermals
  - Lower $R_{DS(on)}$ per package (TO-220, ThinPAK, TO-247)
- Enabling high **power density designs** and **highest efficiency**

Adequate Ease-of-Use

- **600 V CoolMOS™ P7** offers
  - Outstanding commutation ruggedness
  - Smooth switching waveforms
- **600 / 650 V CoolMOS™ CFD7** offers
  - Best-in-class body diode robustness
  - Improved turn-off behavior allows increase of $RG_{on,\,ext.}$ without negative impact on efficiency
- Both series come with a **broad product portfolio** for many different customer needs

Price/performance ratio and quality

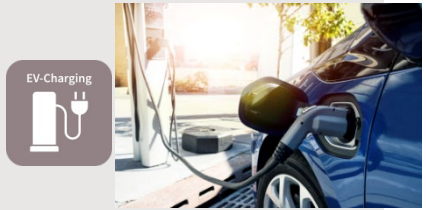
Best-in-class price/performance ratio

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

Granular portfolio

- $R_{DS(on)}$ range from 170 down to 18mΩ in the common TO-247 package
- Allowing the best fit $R_{DS(on)}$ selection

Well known Infineon quality with highest quality standards



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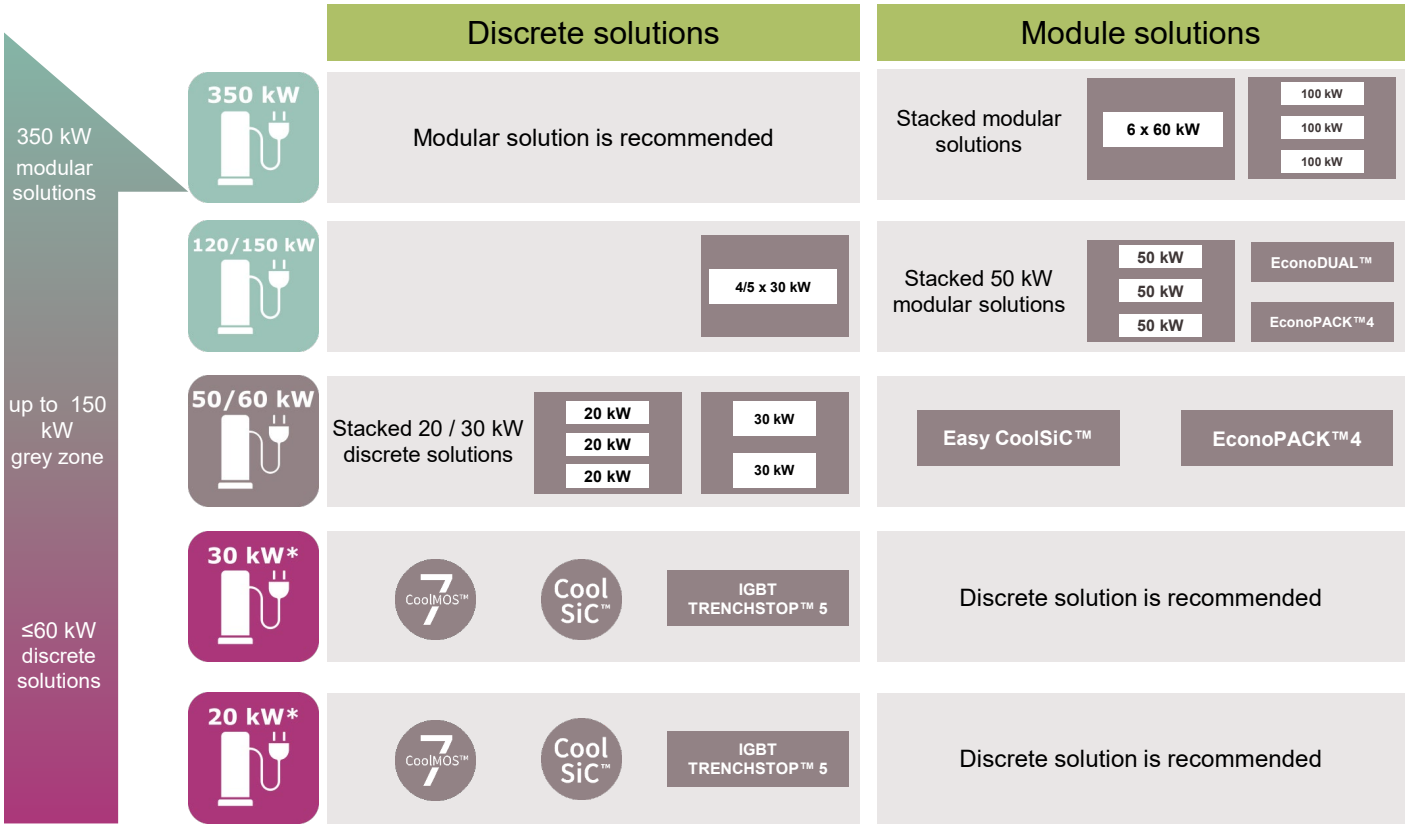
Infineon's power solution positioning for EV charger



* DC charger subunit or DC charger

As a hint: CoolMOS™ for Bias and Auxiliary Power Supplies

Bias Supplies are present in most of our CoolMOS™ applications:

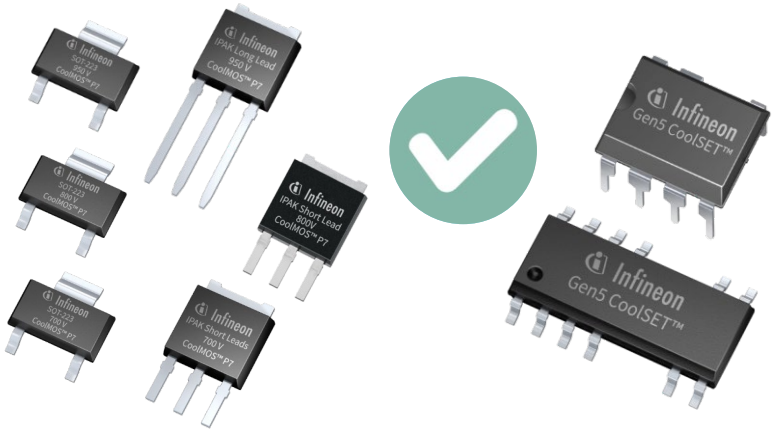
- EV Charging
- Server
- Telecom
- …
- Audio power supplies (with CoolSET™)

Our products for Bias Supplies are:

- CoolMOS™ P7 700 V, 800 V and 950V 5th generation PWM flyback controller

OR

- 5th generation CoolSET™ integrated power stage



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