CoolMOS™ 8 600 V MOSFET

The latest generation of silicon (Si) MOSFETs

About this document

Scope and purpose

This document describes the differences between the earlier generation of CoolMOS™ 7 600 V MOSFETs and the latest CoolMOS™ 8 600 V silicon (Si) MOSFETs from Infineon.

This application note includes various technology parameters and discusses the latest developments, as well as the most significant additional benefits for designers. Finally, the document provides benchmarking against many other available Si MOSFET vendors in the targeted topologies.

Intended audience

The intended audiences for this document are design engineers, technicians, and developers of electronic systems.

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1 Introduction

Infineon's latest CoolMOS™ 8, with 600 V breakdown voltage, is leading the way in high-voltage superjunction (SJ) MOSFET technology worldwide, setting the standard for both technology and price performance on a global scale. It also enables cost-effective Si-based solutions, enhancing Infineon's high-voltage wide bandgap offerings.

The CoolMOS™ 8 series is equipped with an integrated fast body diode, making it suitable for a wide range of applications. This new series is an enhancement of Infineon's existing wide band gap offering and the successor of the CoolMOS™ 7 600 V MOSFET family, which includes P7, S7, CFD7, C7, G7, and PFD7.

CoolMOS™ 8 SJ MOSFET offers a reduced gate charge (Q_g) of 28% over CFD7, a 33% reduction over P7 at 10 V, and a 48% lower C_{OSS} than CFD7 and P7 at 400 V. Its C_{OSS} stored energy (E_{oss}) is further improved by 15% over CFD7 and P7, with the reverse recovery charge (Q_{rr}) being 22% lower than CFD7, having the lowest reverse recovery time (t_{rr}) in the market. The R_{th} thermal performance shows a 30% improvement compared to the previous generation. These values can differ depending on the $R_{DS(on)}$'s and packages.

Due to these features, CoolMOS™ 8 SJ MOSFETs offer the highest efficiency and best-in-class reliability in soft switching topologies such as LLC and ZVS phase-shift full-bridge. Additionally, it offers an outstanding level of performance in PFC and other hard-switching topologies.

In addition, the CoolMOS™ 8 600 V SJ MOSFETs enable higher power density. Thanks to our best-in-class $R_{DS(on)}$ products down to a single digit of 7 mΩ within a Si based SJ technology. The innovative SMD QDPAK, TOLL, and ThinTOLL 8x8 package offerings simplifies the designing process and reduces assembly cost.

1.1 Positioning in comparison to predecessors

The CoolMOS™ 8 600 V MOSFETs offers best-in-class $R_{DS(on)}$ * A and E_{OSS} values, as well as better $R_{DS(on)}$ overtemperature behavior. This leads to increased performance and the new package solutions make it possible to achieve higher power densities, compared to CoolMOS™ 7 600 V series products. CoolMOS™ 8 combines the best features of all CoolMOS™ 7 series products, making it a one-for-all solution that simplifies the overall portfolio. This is especially beneficial for the economy of scale, ease of manufacturing, and simplified part selection.

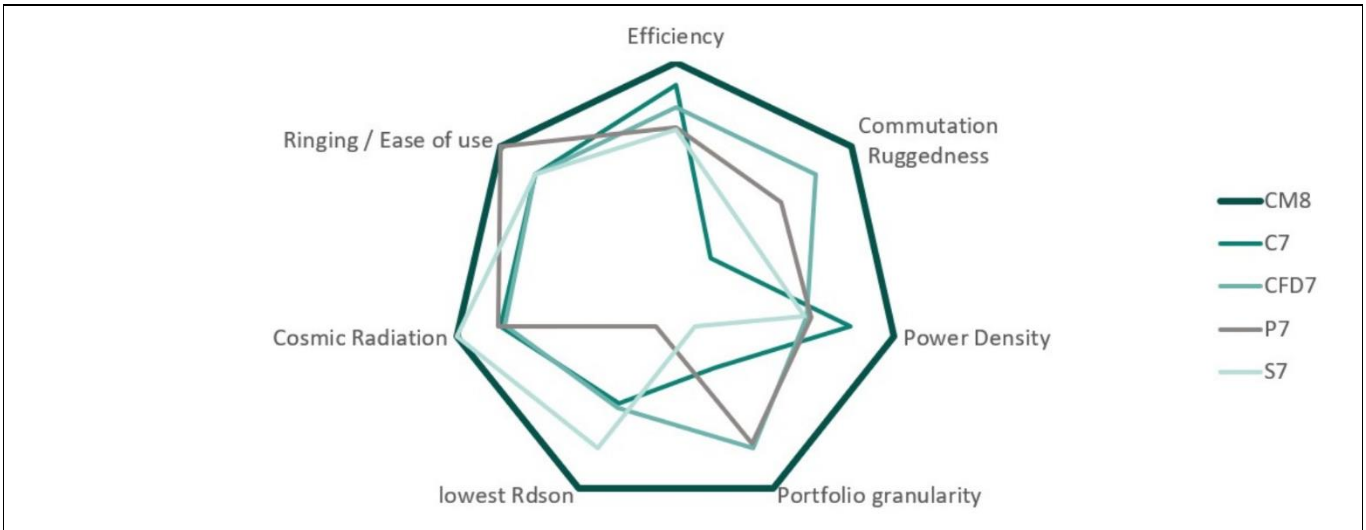


Figure 1 Positioning of the CoolMOS™ 8 600 V against its predecessors

1.2 Portfolio

CoolMOS™ 8 600 V MOSFETs features a wide range of products and packages fitting each requirement (see Figure 2). They are equipped with a fast body diode across the whole portfolio. Thus, the portfolio currently includes the products shown in Figure 2, and will be expanded to include new packages and a range of $R_{DS(on)}$ values.

$R_{DS(on),max}$ [mΩ]	SMD packages					THD packages			
	QDPAK TSC	DDPAK	TOLL	ThinTOLL 8x8	DPAK	TO 247-3	TO 247-4	TO 220	TO 220 FP NL
600					IPD60R600CM8				
180		IPDD60R180CM8	IPT60R180CM8	IPTA60R180CM8	IPD60R180CM8			IPP60R180CM8	IPAN60R180CM8
37	IPDQ60R037CM8	IPDD60R037CM8	IPT60R037CM8			IPW60R037CM8	IPZA60R037CM8	IPP60R037CM8	
16	IPDQ60R016CM8		IPT60R016CM8			IPW60R016CM8	IPZA60R016CM8	IPP60R016CM8	
7	IPDQ60R007CM8								

Samples are available | More to come!

Figure 2 CoolMOS™ 8 600 V MOSFET portfolio

2 Technology parameters

This section compares the key technology parameters of the CoolMOS™ 8 600 V (IPW60R037CM8) with the CoolMOS™ CFD7 600 V (IPW60R040CFD7) and other vendor devices with $R_{DS(on),max}$ ranging from 37 mΩ and TO247-3 package. Although this comparison is valid for other $R_{DS(on)}$ ranges, the values of the parametric results may vary depending on the package, and characterization conditions.

2.1 $R_{DS(on)}$ over junction temperature

In the device datasheets, the typical $R_{DS(on)}$ value is represented at 25°C and 150°C junction temperature. Usually, the devices operate at junction temperatures within this range. Therefore, it is necessary to know the $R_{DS(on)}$ value within this temperature range. The $R_{DS(on)}$ shows a positive temperature coefficient, which results in an increased $R_{DS(on)}$ value at higher temperatures. As shown in Figure 3, the X-axis is the junction temperature, and the Y-axis is the 25°C normalized $R_{DS(on)}$ value. From Figure 4, it is evident that the $R_{DS(on)}$ increase over junction temperature is improved for CoolMOS™ 8 600 V series and shows better performance over CoolMOS™ 7 600 V series and other vendor devices, especially at higher temperatures.

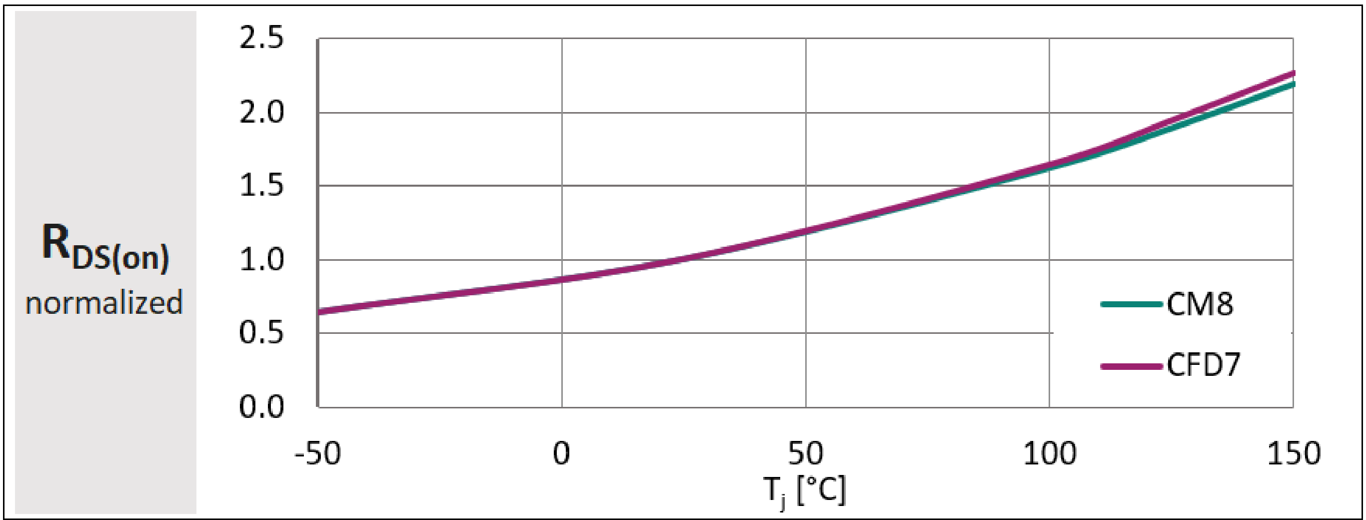


Figure 3 Normalized $R_{DS(on)}$ over junction temperature

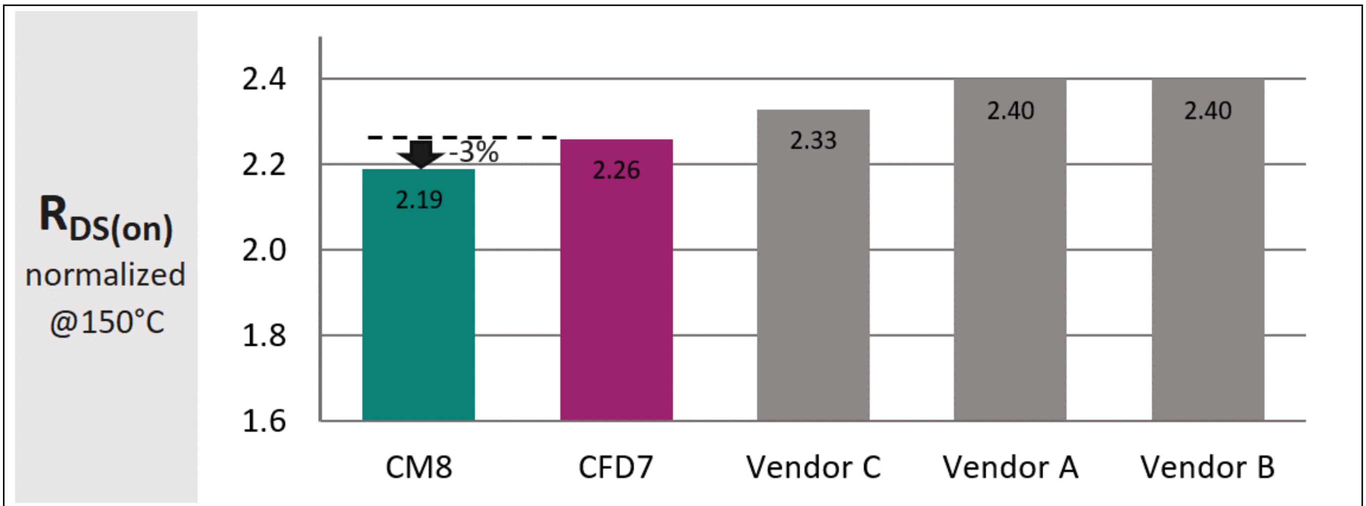


Figure 4 Comparison of datasheet values: Normalized $R_{DS(on)}$ over junction temperature at 150°C

2.2 Output capacitance (C_{oss})

The output capacitance (C_{oss}) is an indicator of the existing switching losses in the device, including the E_{oss}. Figure 5 shows a comparative analysis of C_{oss} at 400 V for the CoolMOS™ 8 and 7 series, along with other vendor devices. The C_{oss} of the CoolMOS™ 8 device is significantly lowered by 48% compared to previous CoolMOS™ generations and other vendor devices.

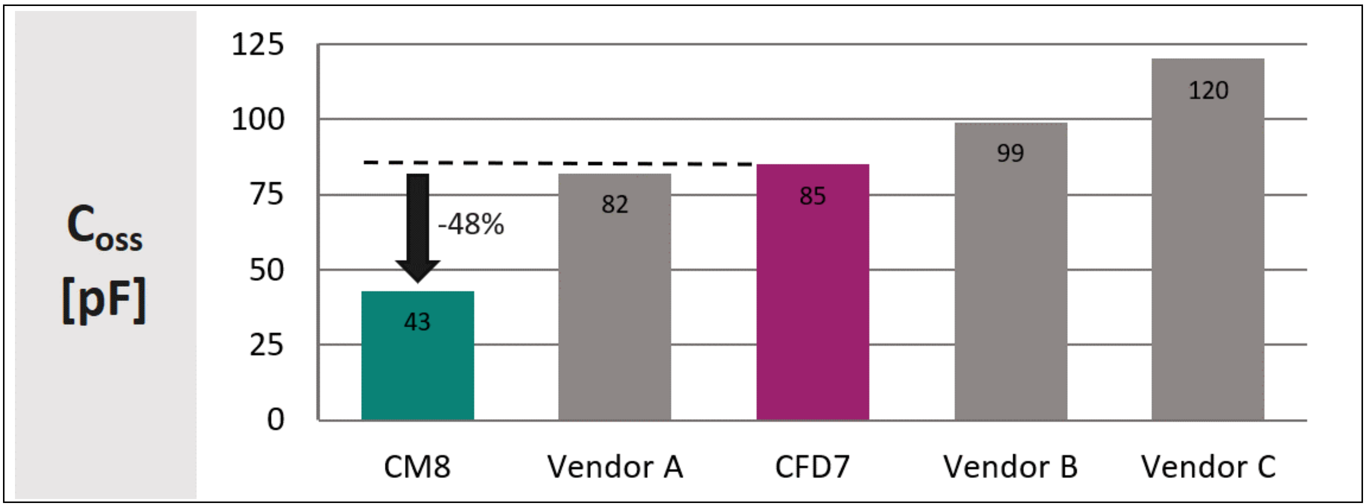


Figure 5 Comparison of datasheet values: Output capacitance at 400 V

Figure 6 shows a comparison of E_{oss} between CoolMOS™ 8, CoolMOS™ 7, and vendor devices. At 400 V, the E_{oss} of CoolMOS™ 8 is reduced by 15% compared to all other devices.

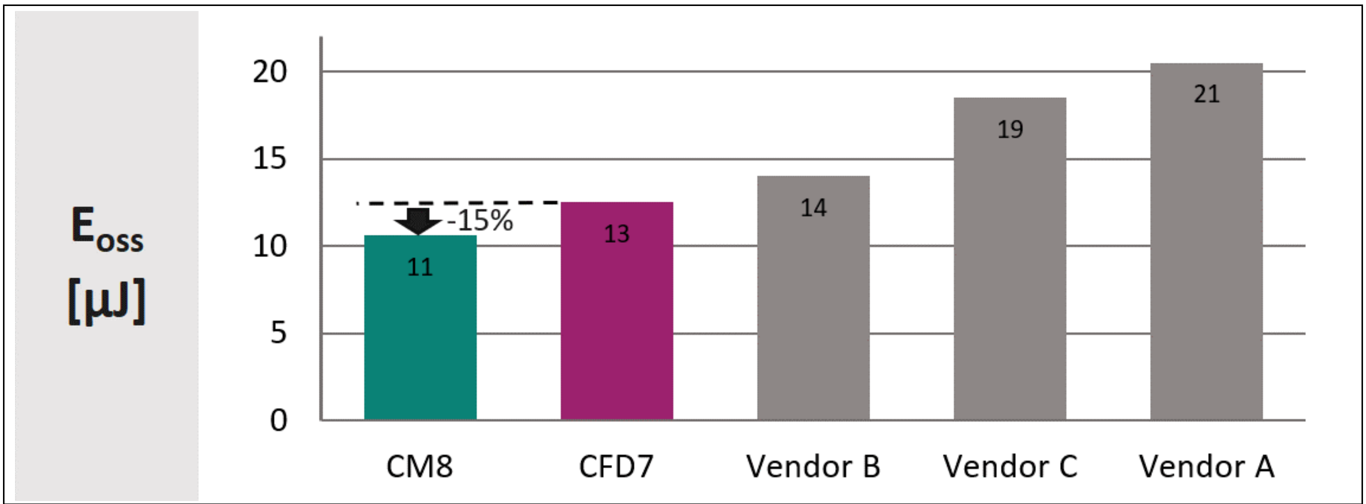


Figure 6 Comparison of datasheet values: C_{oss} stored energy at 400 V

2.3 Gate charge (Q_g)

The gate charge (Q_g) has a significant impact on the driving losses and the switching behavior, affecting the efficiency during light-load operation or increased switching frequency. In Figure 7, the gate charge of CoolMOS™ 8 is reduced by 28% compared to the former CoolMOS™ CFD7. Due to this behavior, CoolMOS™ 8 can support even higher switching frequencies, and allows for increased power density by reducing the size of passive components.

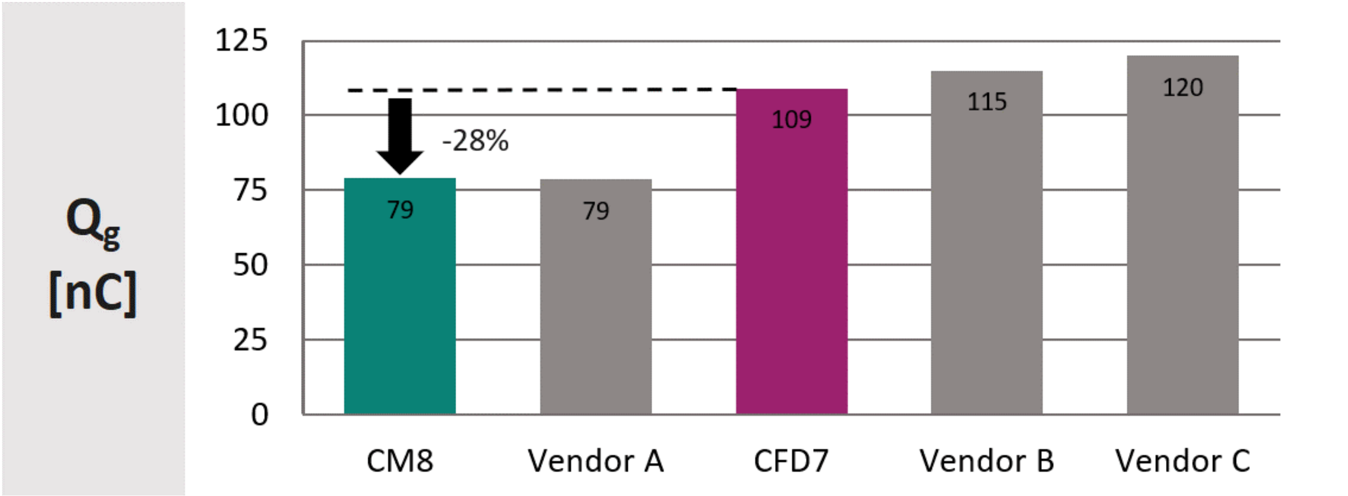


Figure 7 Comparison of datasheet values: Gate charge at 10 V

2.4 Diode characteristics

Generally, repetitive hard commutation at a high application-switching frequency is not recommended for any SJ MOSFET. But, it is unavoidable in certain operating conditions at least for a short period of time. Therefore, the reduced reverse recovery benefits of a fast diode results in much lower power dissipation during these events against other vendors, especially against non-fast-diode solutions. Figure 8 shows the characteristic diode recovery waveform and the points where the characterization measurements are taken for CoolMOS™ 8 devices.

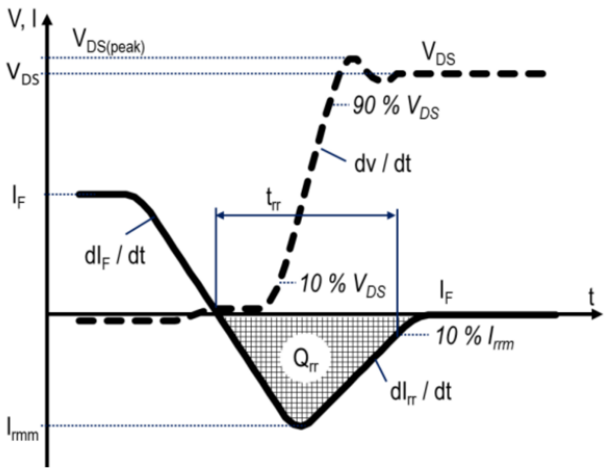


Figure 8 Diode recovery waveform

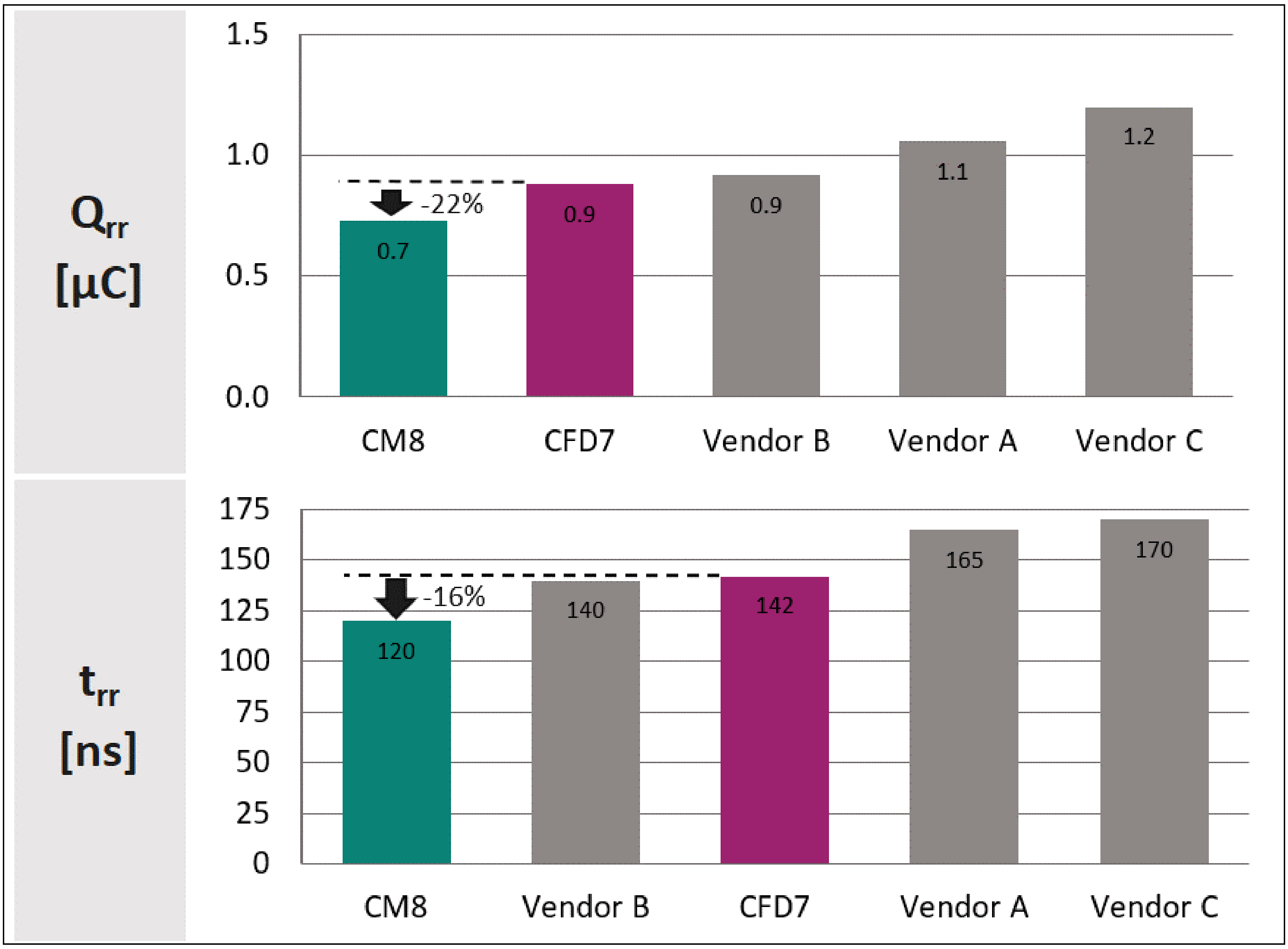


Figure 9 **Comparison of datasheet values: Diode characteristics, Q_{rr} and t_{rr}**

Figure 9 shows a comparison of Q_{rr} and t_{rr} between CoolMOS™ 8 and CFD7, and other vendor devices. It is evident that the body diode behavior of CoolMOS™ 8 shows a substantial improvement over the compared devices. Specifically, the CoolMOS™ 8 device exhibits a 22% improvement in Q_{rr} and a 16% in t_{rr}.

2.5 Transfer characteristics

Due to its increased threshold voltage compared to CoolMOS™ 7, CoolMOS™ 8 requires a slightly higher gate- source voltage to carry the full current. However, at typical driving voltages used in applications (>10 V), CoolMOS™ 8 can carry more current than CoolMOS™ 7 (see Figure 10).

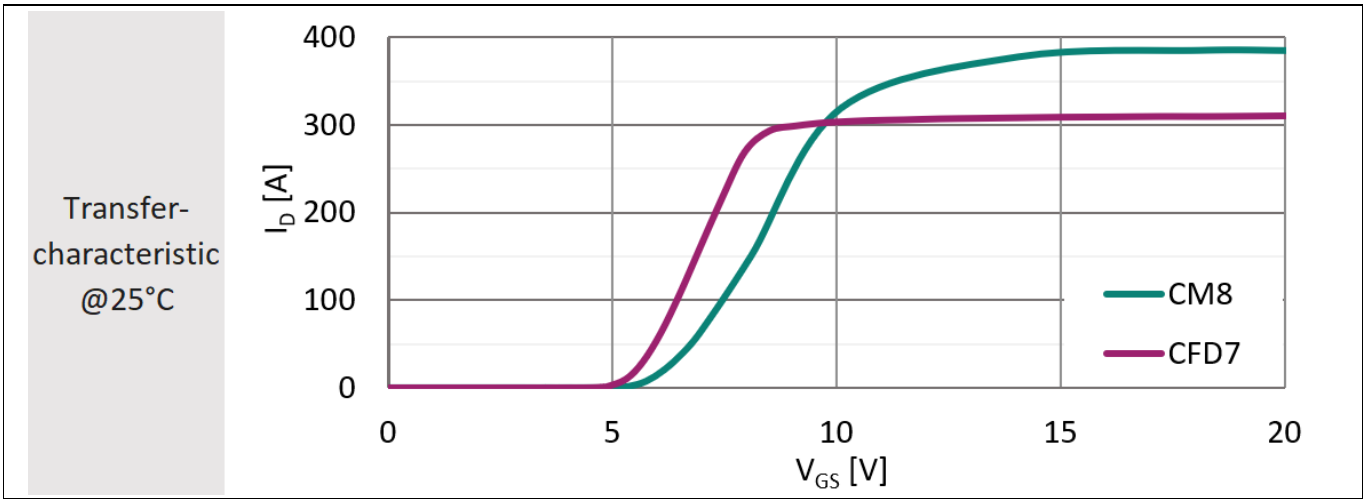


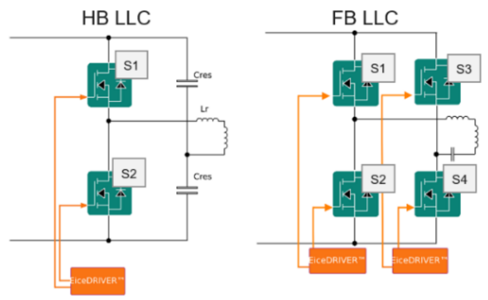
Figure 10 Transfer characteristics

3 Applications

CoolMOS™ 8 600 V MOSFETs enables the usage of one Si MOSFET family across all main topologies and applications, addressing existing and growing market demands. This chapter includes application examples as well as performed application tests.

3.1 Application examples

Figure 11 shows various application examples where the latest CoolMOS™ 8 600 V can be used. CoolMOS™ 8 is a versatile device, offering the best price-to-performance ratio. It is available in various SMD packages that can help reduce the assembly cost. Figure 11 shows a typical LLC application both in half- and full-bridge configuration. Figure 12 shows a totem-pole PFC where CoolMOS™ 8 can be used in combination with CoolSiC™ or CoolGaN™.



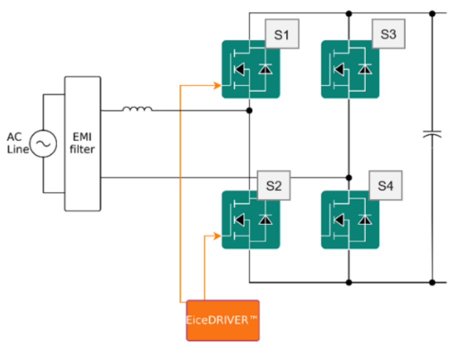
S1, S2, S3, S2	– CoolSiC™ MOSFET 650 V – CoolGaN™ HEMT 600 V / 650 V – **CoolMOS™ 8**
Gate Driver ICs	– EiceDRIVER™ 2EDR9259Y – EiceDRIVER™ 2EDF9275F

Application	System Power	Package	$R_{DS(on)}$ range
Server SMPS	1 kW → 3 kW (or more with interleaving)	TOLL, TO-247, QDPAK	40-70 mΩ
Telecom SMPS	500 W → 3 kW (or more with interleaving)	TOLL, TO-247, QDPAK	20-70 mΩ
EV charging	7 kW → 50 kW (stacked / multilevel and interleaving)	TO-247, QDPAK, TOLL	7-37 mΩ
Industrial SMPS, LEV, battery formation, industrial automation	0.8 kW → 8 kW	TOLL, TOLT, TO-247, TO220, QDPAK	7-95 mΩ

CoolMOS™ 8 value proposition

- Best price performance with CoolMOS™ 8
- One stop shop full
- Broad SMD package offering to enable assembly cost reduction

Figure 11 CoolMOS™ 8 in LLC converter



S1, S2	– CoolSiC™ MOSFET 650 V – CoolGaN™ HEMT 600 V / 650 V
S3, S4	– **CoolMOS™ 8**
Gate Driver ICs	– EiceDRIVER™ 2EDB9259Y – EiceDRIVER™ 2EDF9275F

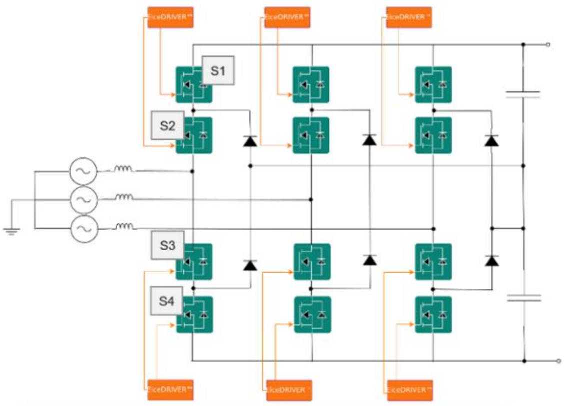
Application	System Power	Package	$R_{DS(on)}$ range
Server SMPS	1 kW → 3 kW (or more with interleaving)	TOLL, TO-247, QDPAK	16-180 mΩ
Telecom SMPS	500 W → 3 kW (or more with interleaving)	TOLL, TO-247, QDPAK	16-99 mΩ
Industrial SMPS, LEV, battery formation, industrial automation	0.8 kW → 8 kW	TOLL, TO-247, QDPAK, TO-220	7-95 mΩ
Solar microinverters	0.8 kW → 1.6 kW	TOLL, QDPAK	50-70 mΩ
RAC PFC	1 kW → 4 kW	TOLL, TO-247, QDPAK	40-99 mΩ

CoolMOS™ 8 value proposition

- Best price performance with the combination of CooSiC™ 650V G2 and CoolMOS™ 8
- One stop shop full Totem Pole solution
- Broad SMD package offering to enable assembly cost reduction

Figure 12 CoolMOS™ 8 combined with CoolSiC™ and CoolGaN™ in totem-pole PFC

The combination of CoolMOS™ 8 and CoolSiC™ benefits inverter applications by further improving the price performance ratio (see Figure 13).



Application	System Power	Package	$R_{DS(on)}$ range
EV charging including LEV, MicroEV, Folklift, Wireless, eBike	Up to 22kW	TO-247, QDPAK, TOLL	7-180 mΩ
Residential Solar and ESS	Up to 7kW	TO-247, QDPAK TOLL	16-180 mΩ

S2, S3	– 650 V CoolSiC™ MOSFET
S1, S4	– **CoolMOS™ 8**
Gate Driver ICs	– EiceDRIVER™ 2EDB9259Y – EiceDRIVER™ 2EDF9275F

CoolMOS™ 8 value proposition

- Best possible system level power density with Si solution on the market today
- Available in TSC SMD to enable assembly cost reduction

Figure 13 CoolMOS™ 8 combined with CoolSiC™ in bidirectional three level inverter

As CoolMOS™ 8 exhibits a very low $R_{DS(on)}$ value of 7 mΩ, it is suitable for the growing market of solid-state relay applications, offering a cost-optimized alternative to CoolSiC™ (Figure 14). Compared to mechanical relays, solid-state relays switch faster, do not have contact arching or bouncing and therefore have a longer system lifetime. Additionally, they are designed to withstand shocks and vibrations, ensuring a quite operation.

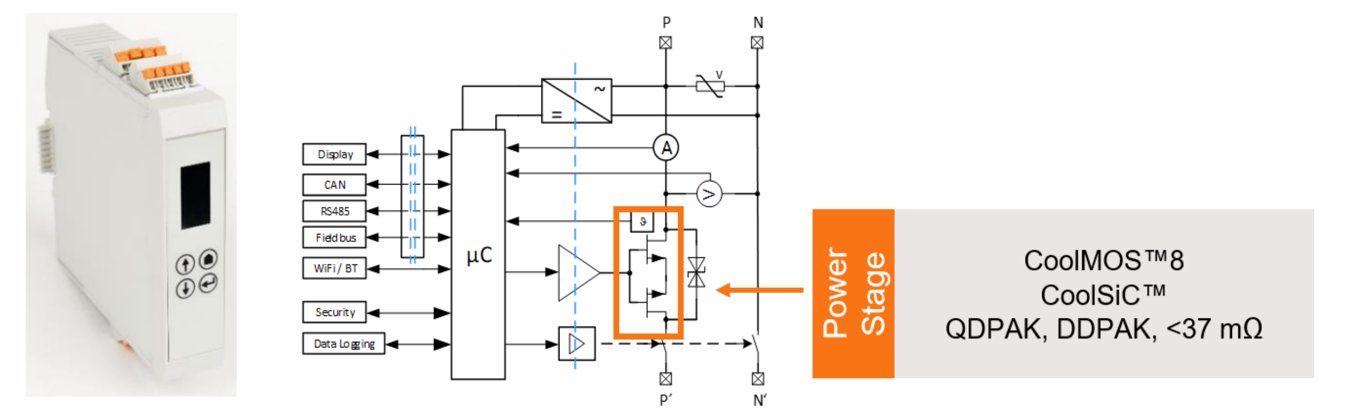


Figure 14 CoolMOS™ 8 in solid state relay applications

For more information, see High-voltage solid-state power distribution.

3.2 Application measurements

This section benchmarks the performance of CoolMOS™ 8 600 V with CoolMOS™ 7 600 V series and other latest silicon MOSFET devices from various vendors.

3.2.1 Efficiency comparison in a 3.3 kW LLC

Figure 15 shows the efficiency comparison between IPW60R037CM8 and IPW60R040CFD7, as well as the latest vendor devices of the same $R_{DS(on)}$ range featuring a fast body diode. The comparison studies are performed using Infineon's 3.3 kW LLC evaluation board, representing a soft-switching application. When comparing the peak efficiency, CoolMOS™ 8 shows an improvement in efficiency by 0.04% over CoolMOS™ CFD7, and it is well ahead of other vendors by 0.05% to 0.11%. Table 1 shows the measurement conditions used for this test. Each part has been optimized to achieve optimal performance.

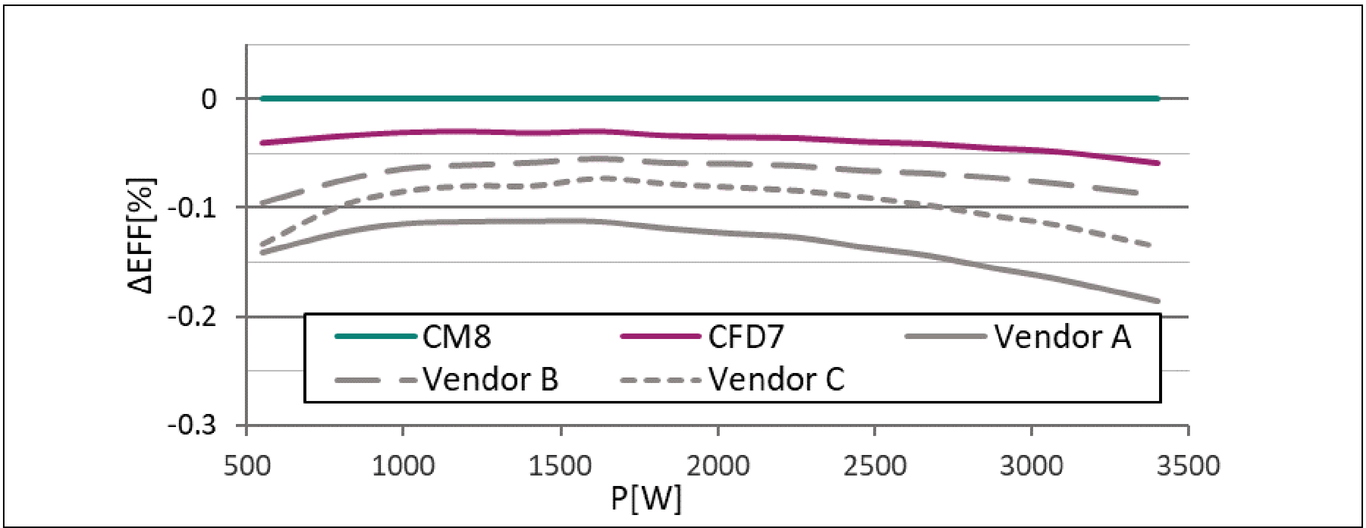


Figure 15 Efficiency comparison in Infineon 3.3 kW LLC Evaluation Board (order code: EVAL_3K3W_LLC_HB_CFD7)

Table 1 LLC measurement conditions

Device	Rg,on [Ω]	Rg,off [Ω]	Min. dead-time [ns]	Max. dead-time [ns]
IPW60R037CM8	5	2	350	550
IPW60R040CFD7	3	1	375	500
Vendor A	3	0	337.5	625
Vendor B	3	1	400	675
Vendor C	3	1	387.5	650

3.2.2 Efficiency comparison in a 2.5kW CCM PFC

Figure 16 shows the comparison of IPW60R037CM8 and IPW60R040CFD7, including the latest vendor devices of the same $R_{DS(on)}$ range and with a fast body diode feature. For this purpose, two measurements with a MOSFET switching frequency of 80 kHz have been performed using Infineon's 2.5 kW CCM PFC evaluation board. One of the measurements is conducted at 230 V_{AC} / 50 Hz input voltage, and the other is performed at 90 V_{AC}/60 Hz. For all measured devices, the same $R_{g,sum}$ (= $R_{g,int}$ + $R_{g,ext}$) of 7 Ω has been used.

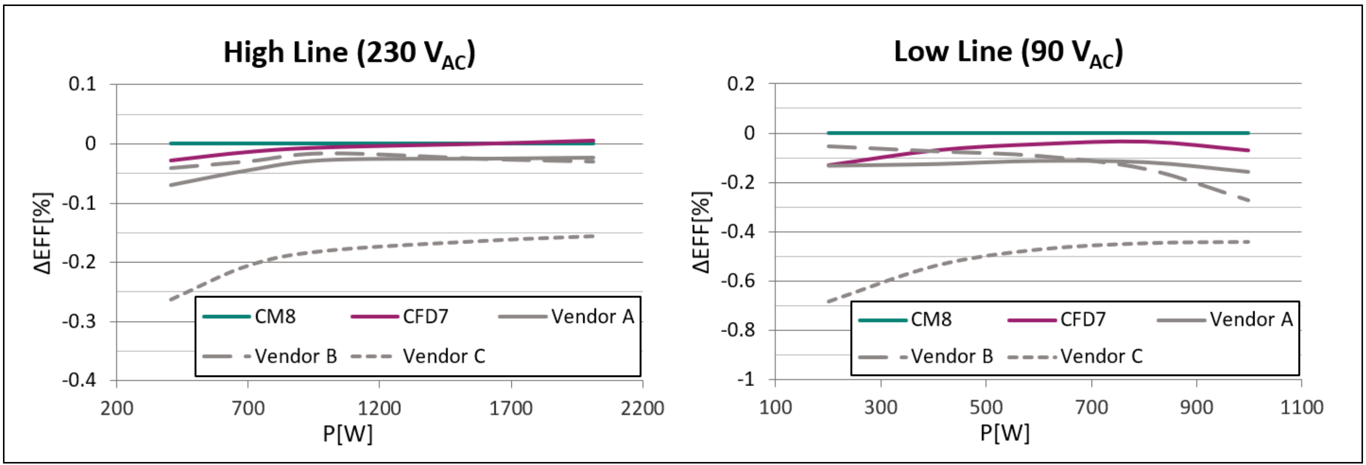


Figure 16 Efficiency comparison in a 2.5 kW CCM PFC at 80 kHz (order code: EVAL_2K5W_CCM_4P_V3)

CoolMOS™ 8 shows a performance improvement over CoolMOS™ CFD7 and other vendors, especially in the low-line measurement, where the stress on the devices is larger compared to the high-line measurement.

Figure 17 shows the efficiency comparison between IPW60R016CM8, IPW60R018CFD7, and IPW60R017C7 at 130 kHz MOSFET switching frequency, conducted using the same test platform. It is evident that the performance difference between the CoolMOS™ 7 and CoolMOS™ 8 devices get even larger (>0.05% at low-line, >0.1% high-Line) at higher switching frequency. The increased performance of CoolMOS™ 8 over the CoolMOS™ 7 series is due to the reduced switching losses, which become more dominant at high switching frequencies. For all measured devices used in this comparison, the same $R_{g,sum}$ (= $R_{g,int}$ + $R_{g,ext}$) of 5 Ω has been used.

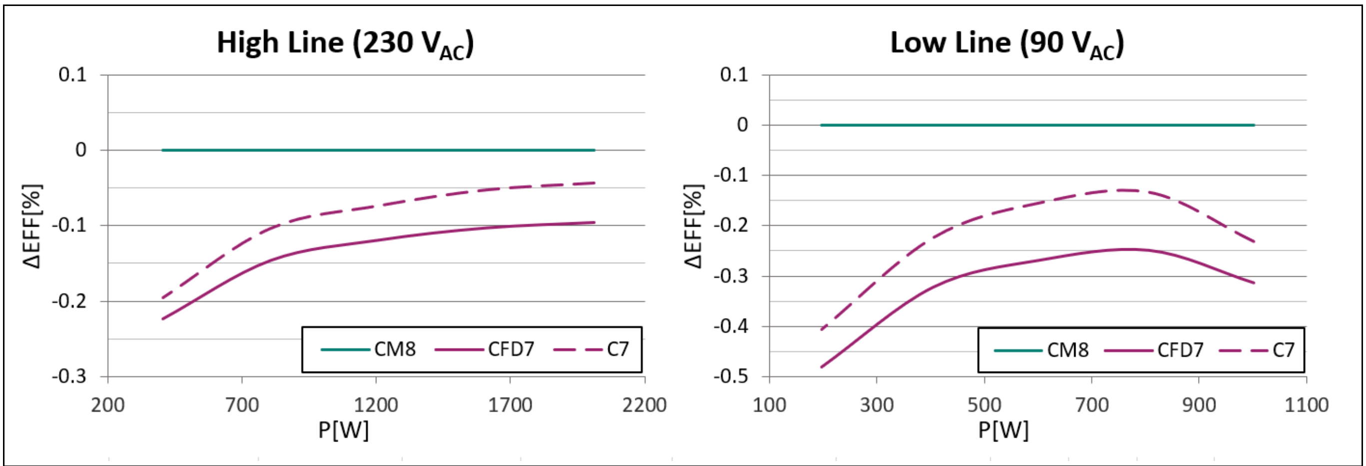


Figure 17 Efficiency comparison in a 2.5 kW CCM PFC at 130 kHz (order code: EVAL_2K5W_CCM_4P_V3)

3.2.3 Ease-of-use testing (ringing)

Figure 18 shows the gate ringing oscillations of CoolMOS™ 8 600 V (IPP60R180CM8) in comparison with CoolMOS™ P7 600 V (IPP60R180P7). The V_{GS} peak is measured using a typical PFC stage with a 5 pF capacitive coupling between the gate and drain to emulate the parasitic capacitance of the PCB, while continuously increasing the switched drain current. The layout parasitic capacitance can be a source of noise on the gate switching waveforms, especially with increasing load current. In the measurements, CoolMOS™ 8 and CoolMOS™ P7 show an excellent gate switching waveform even with reduced the reduced Q_g of CoolMOS™ 8. This provides plenty of margin before reaching the ±30 V gate ringing specification limit within normal operation current levels. For both parts an $R_{g,sum}$ (= $R_{g,int}$ + $R_{g,ext}$) of 15 Ω has been used. The measurements were carried out up to a current of 18 A, which is the maximum continuous current specified in the datasheet, covering all application relevant working points.

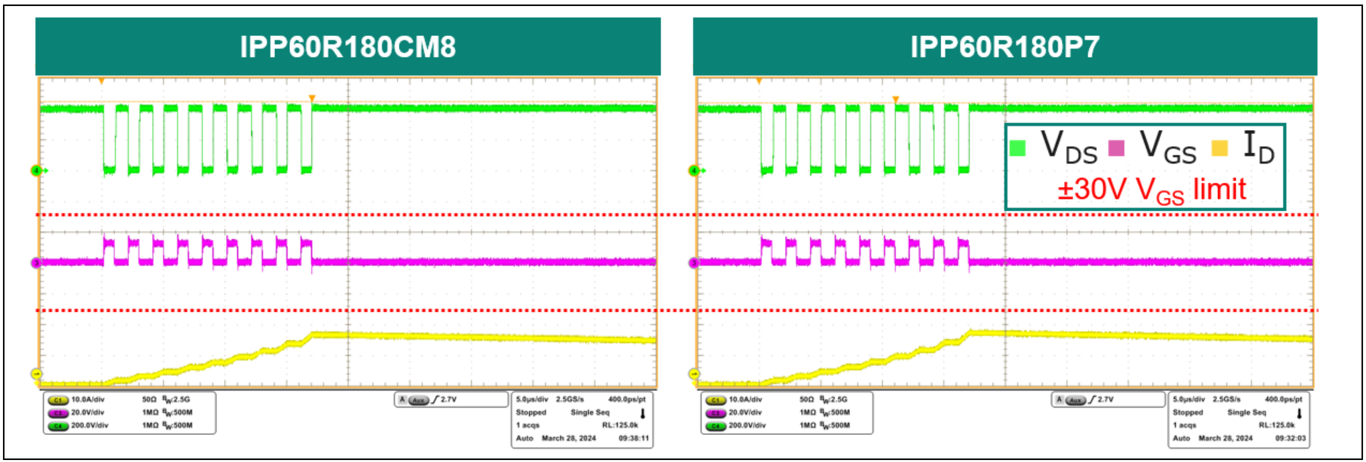


Figure 18 Ringing comparison of 180 mΩ devices with 15 Ω $R_{g,sum}$ and 5 pF external C_{gd}

Figure 19 shows another comparison between CoolMOS™ 8 600 V (IPW60R016CM8) and CoolMOS™ CFD7 600 V (IPW60R018CFD7) with a lower $R_{DS(on)}$. With a relatively low $R_{g,sum}$ (= $R_{g,int}$ + $R_{g,ext}$) of 5 Ω, both devices stay within the ±30 V gate ringing specification limit even at the highest currents, up to 90 A. However, it is visible that CoolMOS™ 8 has slightly more ringing at high currents compared to CoolMOS™ CFD7. This can be mitigated by a minor increase in the external gate resistor.

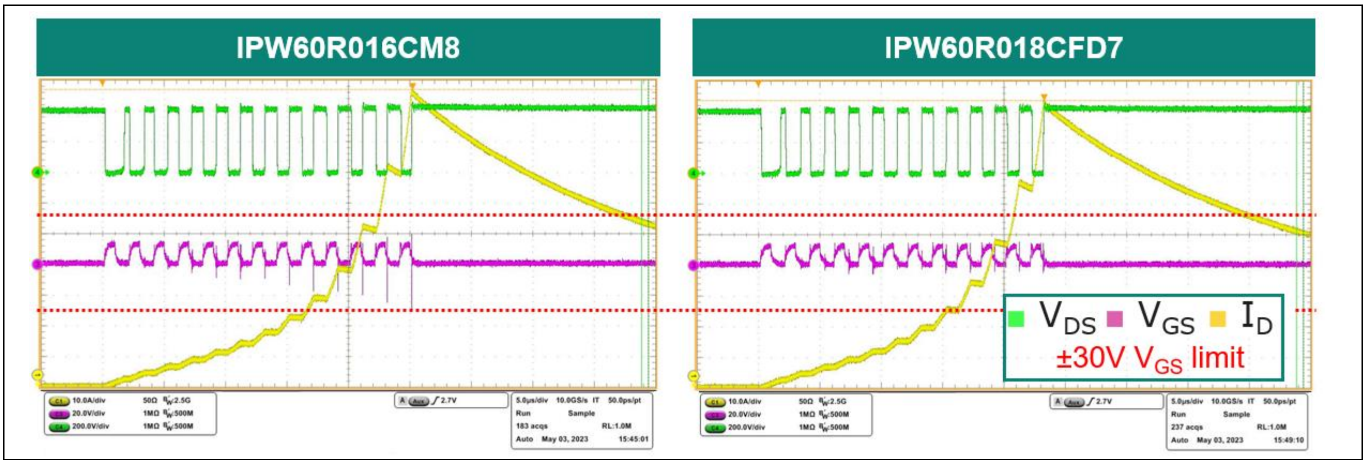


Figure 19 Ringing comparison of 16 mΩ devices with 5 Ω $R_{G,sum}$ and 5 pF external C_{gd}

4 Package innovations

This chapter introduces the new ThinTOLL package and highlights the advantages of using top-side-cooled packages.

4.1 Top-side-cooled packages

The last decade of SMPS development was dominated by the trend towards higher power density and cost optimization. Fastest switching, highest efficiency, and optimized board space at minimized total cost of ownership (TCO) are among the critical on-going challenges faced by power supply designers. Until now, the most common packages on the market were the well-established through-hole devices (THDs), such as TO-220 and TO-247. Owing to the steadily increasing requirements in the semiconductor market, there is a growing trend towards using SMD packaged devices, as they support faster switching speeds and reduced parasitic inductance. For these reasons, SMD packaged devices are preferred over THD packages. Despite its advantages, they still pose a significant challenge regarding cooling. To push these boundaries, Infineon, in 2023, has successfully registered its QDPAK and DDPAK top-side cooling packages, which are ideal for high-voltage MOSFETs as a JEDEC standard.

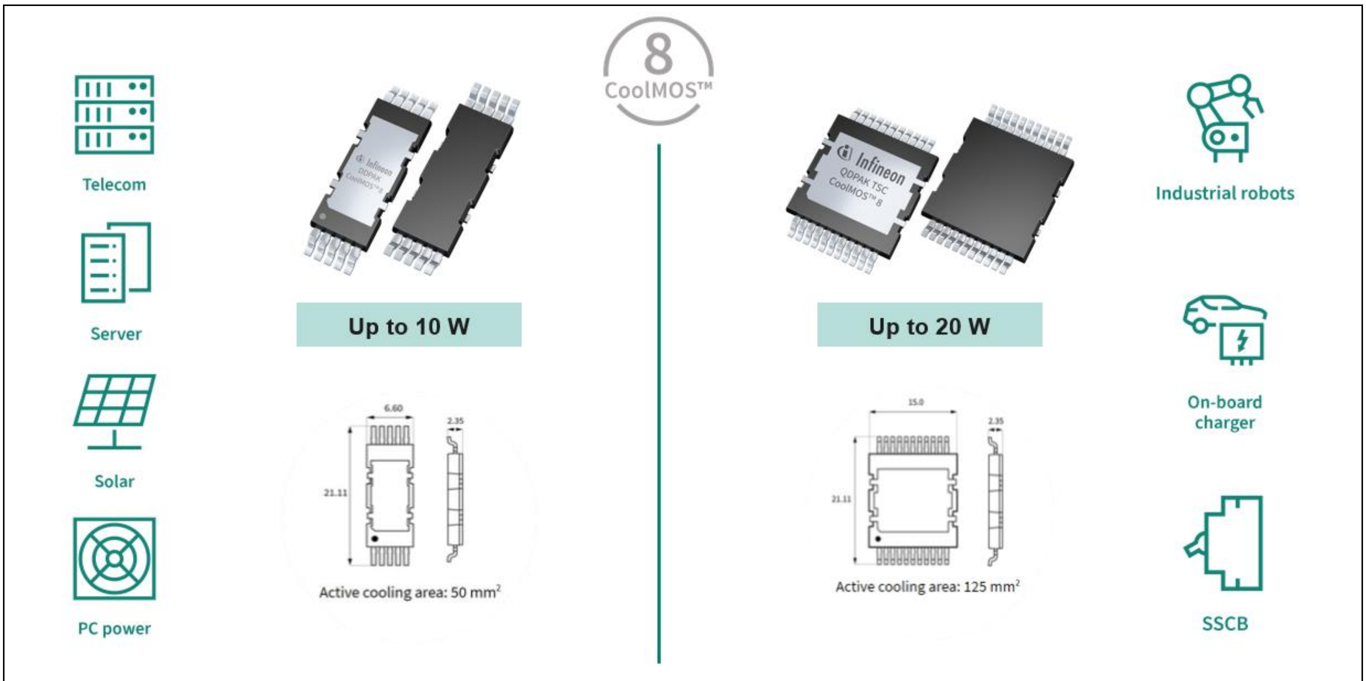


Figure 20 DDPAK and QDPAK TSC packages

4.2 Advantages of top-side-cooled packages

The well-established THD like TO220 or TO247 are coming to their end in terms of power capabilities and supporting the trend towards increased power densities in the end application.

With the TSC package, it is possible to decouple the heat transfer between PCB and package on the bottom side, while adding flexibility in terms of cooling. It is also possible to mount a heatsink on top, or the package can be mounted towards a housing for an additional cooling area.

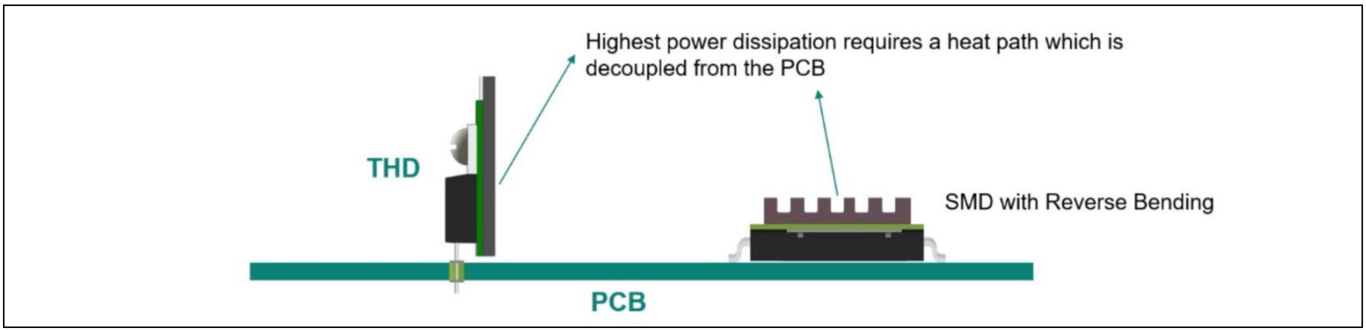


Figure 21 **THD vs TSC package mounting**

The thermal decoupling between PCB and package enables lower PCB temperature (approximately 10 °C) at the same power dissipation when comparing a TSC package with a standard SMD package, such as TOLL. In many applications, the PCB material limits the maximum allowed temperature, typically around 110°C for FR4. Lowering the temperature by 10°C via thermal decoupling, is beneficial for the system's lifetime and it allows for the power dissipation due to the additional headroom.

On the whole, the usage of top-side-cooled SMD packages enables a new approach towards smaller form factors, increased power density, and improved thermal management.

4.2.1 Mounting of top-side-cooled packages

Infineon's top-side-cooled packages offer a solderable top side, where a heatsink can be directly soldered to the package. For this, it needs to be taken to account that the top-side of the package is not isolated. The heatsink can also be mounted using push pins and a gap filler between heatsink and package. Another possibility to mount the parts is using a daughter card directly to the heatsink. This can be done with screws, clips, or bond ply, which is a special type of sticky thermal interface material. All the mounting methods are summarized in the following figure. For more information, see the References section and the QDPAK/DDPAK packages.

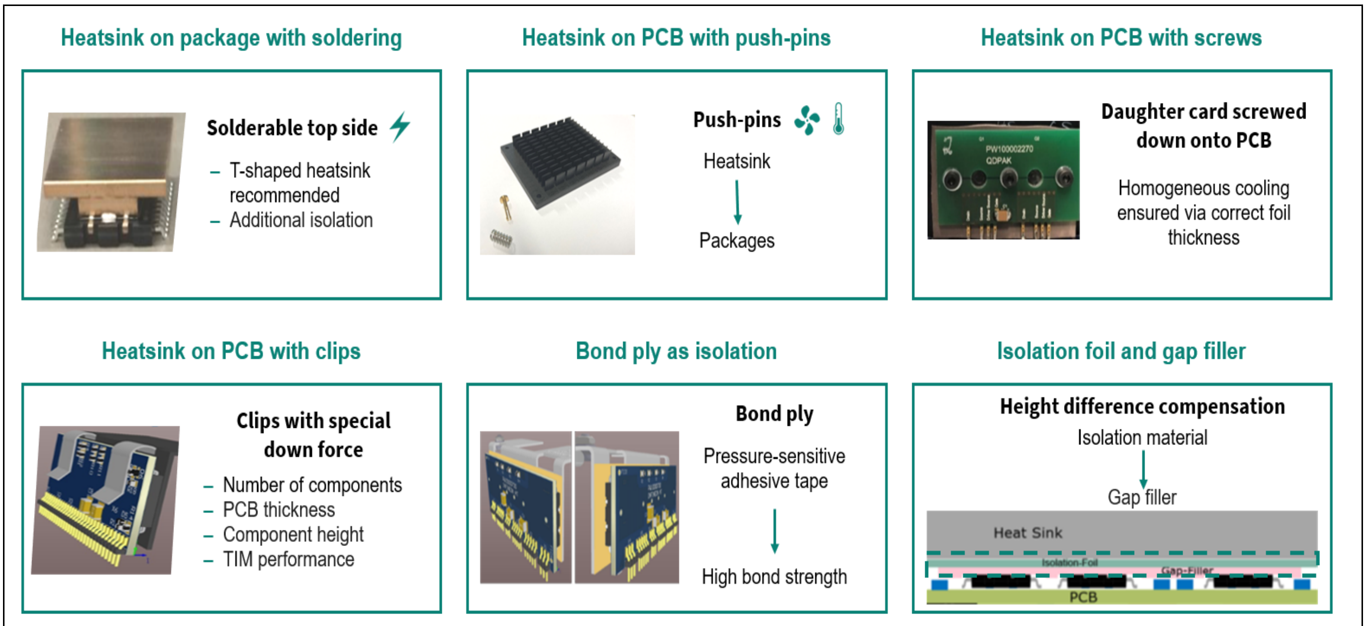
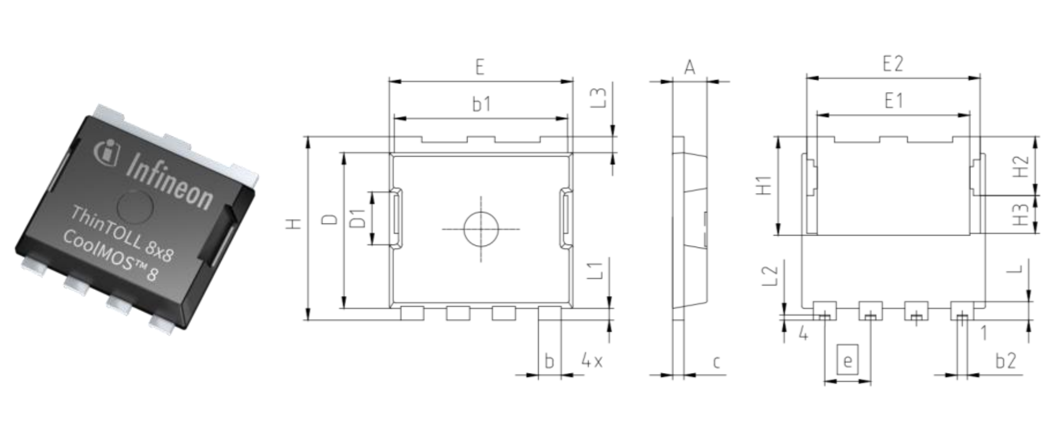


Figure 22 **Mounting possibilities of TSC packages**

4.3 The new ThinTOLL (former ThinPAK)

Infineon introduces the new ThinTOLL 8x8 package as the follower of the ThinPAK 8x8. Compared to the ThinPAK 8x8, ThinTOLL 8x8 has several advantages such as enabling visual solder inspections, Pb free, and MSL1 compliancy, improved Z_{th} (same R_{thJC}), as well as keeping the same footprint and pinout enabling second source capability.

Additionally, the temperature cycling on board (TCoB) is improved by a factor of four making the package more reliable. However, the ThinTOLL 8x8 package is slightly higher than the ThinPAK 8x8 (1.5 mm vs. 1 mm), but this is no blocking point for most applications. Figure 23 shows the package outlines of ThinTOLL 8x8, and Figure 24 shows the difference between ThinTOLL and ThinPAK 8x8.



PACKAGE - GROUP NUMBER:	PG-LHSOF-4-U01	
DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	1.40	1.60
b	0.90	1.10
b1	7.46	7.66
b2	0.42	0.50
c	0.40	0.60
D	6.59	6.99
D1	2.30	
E	7.80	8.20
E1	6.66	
E2	7.56	
e	2.00	
N	4	
H	7.80	8.20
H1	4.30	
H2	2.57	
H3	1.65	
L	0.50	1.00
L1	0.51	
L2	0.23	
L3	0.50	0.90

Figure 23 ThinTOLL 8x8 package (PG-LHSOF-4)

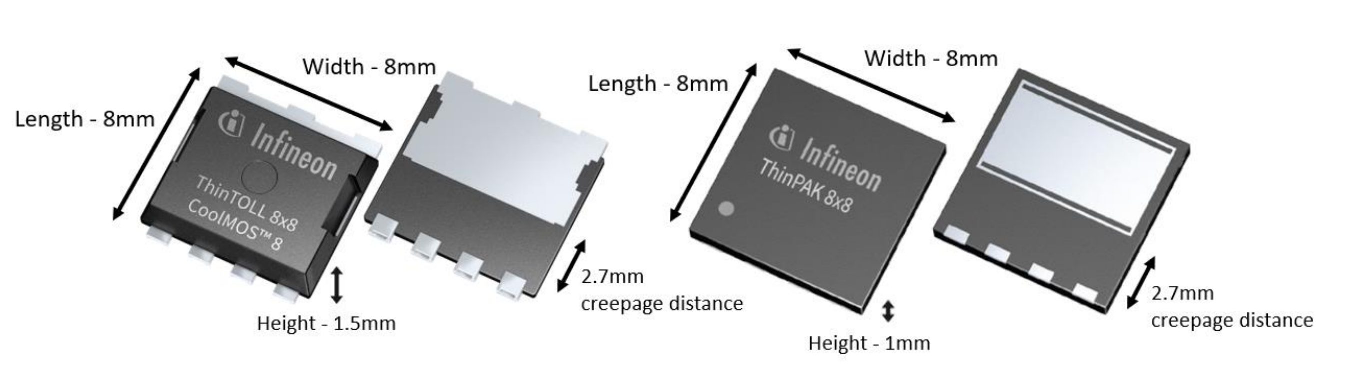


Figure 24 ThinTOLL 8x8 vs. ThinPAK 8x8

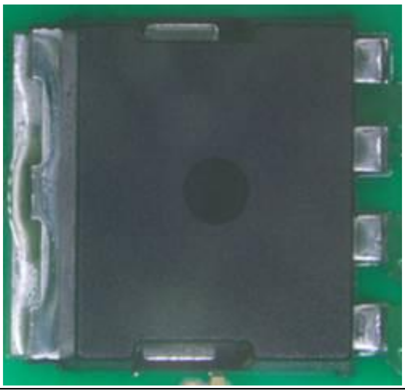


Figure 25 ThinTOLL 8x8 soldered on PCB

As shown in Figure 25, an optical solder inspection can be performed easily on the leads of the ThinTOLL 8x8 package. Besides this, the ThinTOLL 8x8 can be mounted using reflow or wave soldering.

Therefore, the new package innovation simplifies design-in and allows for high-scale mass production, while also improving qualitative advantages such as TCoB performance.

4.4 Benefits of Kelvin source

As the new generations of power switches continue to operate at higher speeds, the effect of the parasitic elements associated with the packages and boards drastically limits the overall system performance. In many applications, the switching losses are significantly increased due to the negative feedback caused by the parasitic inductance in the source lead of the power switch.

An effective measure to overcome this problem is to provide an additional connection to the source (Kelvin connection). This is used as a reference potential for the gate driving voltage, thereby eliminating the effect of voltage drops over the source inductance (see Figure 26). For more information, see the References section.

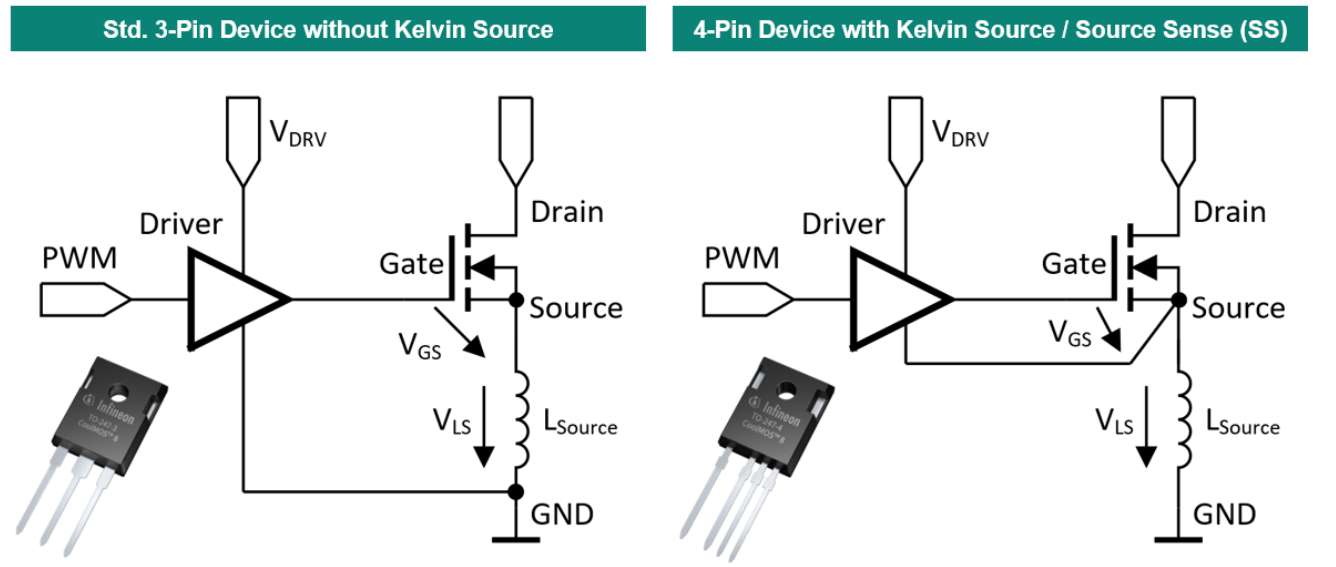


Figure 26 Difference between Kelvin source and non-Kelvin source MOSFET driving

5 EiceDRIVER™ gate drivers

For achieving the best switching performance, a good gate driver is required. Infineon's EiceDRIVER™ gate drivers and the CoolMOS™ 8 600 V MOSFETs are an ideal combination in many applications. Figure 27 shows a summary of Infineon's broad EiceDRIVER™ portfolio featuring single and dual-channel, as well as galvanically- isolated and non-isolated drivers.

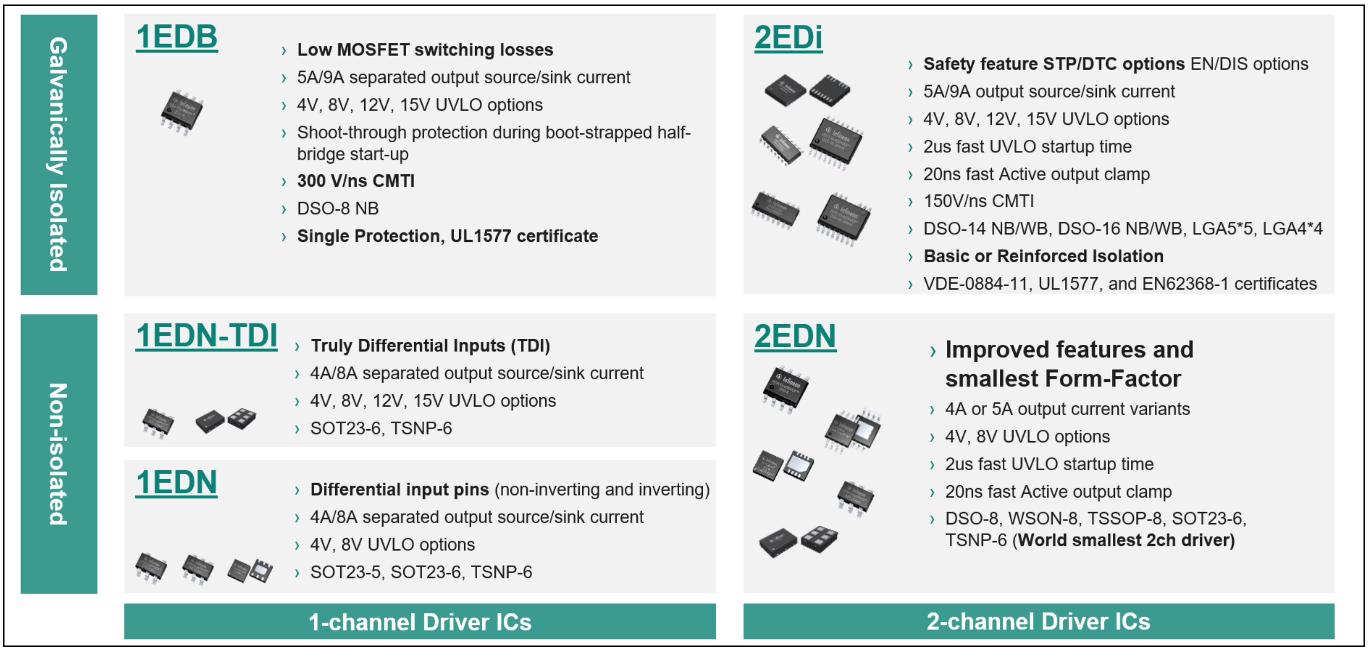


Figure 27 Infineon's EiceDRIVER™ portfolio

New EiceDRIVERs™ gate drivers are available in a narrow height package that complements the top-side-cooled power MOSFETs. These EiceDRIVER™ gate drivers, with a maximum height of 1.65 mm, can fit together with the MOSFET underneath the same heatsink (see Figure 28). For more information, see the Gate Driver ICs.

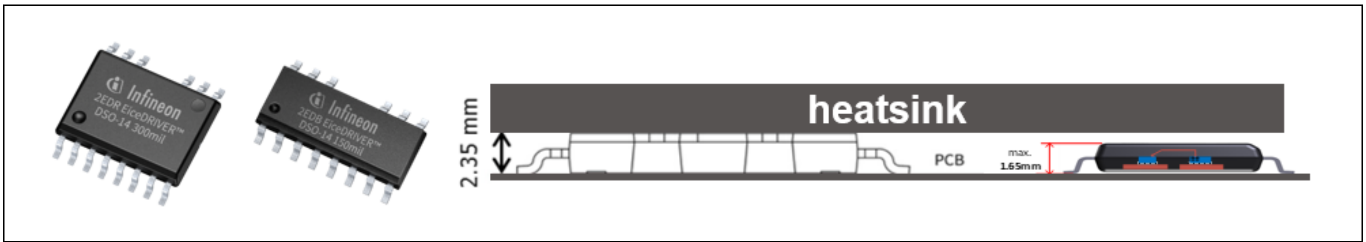


Figure 28 New narrow height EiceDRIVER™

6 Support material

Tailored support material for the CoolMOS™ 8 600 V MOSFETs can be found at www.infineon.com/coolmos8.

Additionally, this section will show two demo boards using the latest CoolMOS™ 8 in combination with CoolSiC™ and CoolGaN™ devices from Infineon Technologies, demonstrating the wide product to system approach.

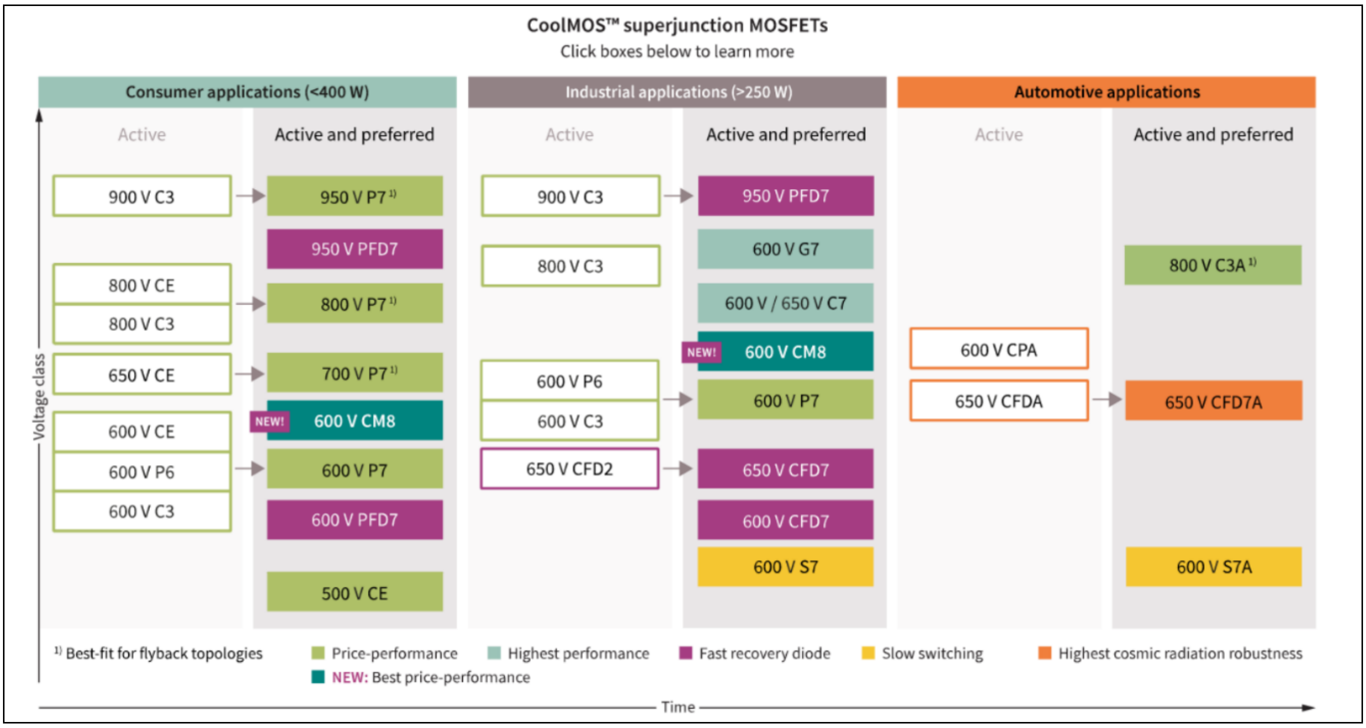
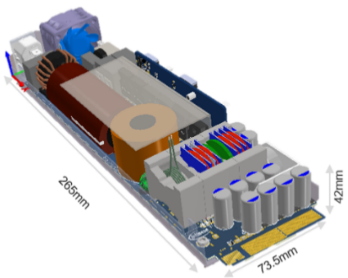


Figure 29 Overview on CoolMOS™ products

6.1 Demo boards

2.7kW PSU Evaluation Board (EVAL_2K7W_12V_PSU)

>96% efficiency



Technical details

Key requirements	Value
Input voltage range	180 V_{AC} ~ 275 V_{AC}
Output voltage	12 V_{dc}
Output current	224 A
Output power	2700W
Peak Efficiency	> 96%
Dimension & Power density	265mm X 73.5mm X 42mm, 3300W/L, 54.1W/in
Power factor (load > 20%)	0.9
Hold up time at full load	10ms

Learn More

Infineon components	Power Devices:IMZA65R072M1H, IPW60R037CM8, IPW60R024CFD7, BSC007N04LS6 Drivers: 2EDB9259Y, 2EDB8259Y, 2EDR8259X, 2EDN7534F, 1EDB8275F Microcontrollers: XMC1404-F064X0200 AA, XMC4200-F64K256BA Digital Isolator: 4DIR1400H Miscellaneous Devices: ICE2QR2280G, TLS202B1V50, IDP40E65D2

Features

- High efficiency bridgeless totem-pole PFC + LLC converter for DC/DC stage
- High power density
- Enabled by CoolSiC™ 650V + CoolMOS™ 8 600V
- Digitally controlled with XMC1404 (PFC) and XMC4200 (LLC)
- Exploring variable PFC switching frequency to reduce inductor size and/or losses

Benefits

- Compact form factor
- Low component count

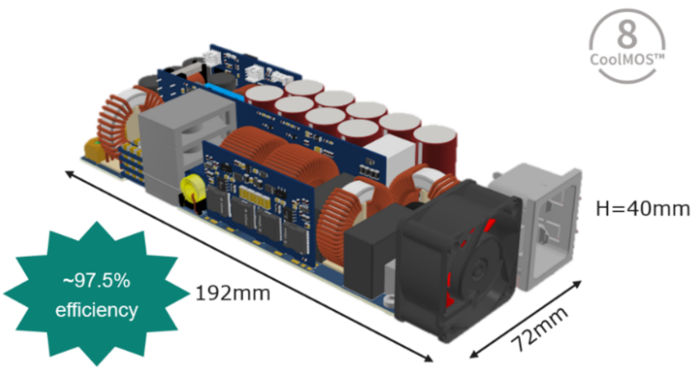
Figure 30 2.7 kW PSU Evaluation Board (order code: EVAL_2K7W_12V_PSU)

The 2.7 kW power supply with its 180 V_{AC} to 275 V_{AC} input and 12 V_{DC} output, demonstrates a state-of-the-art AC to DC unit with an overall peak efficiency greater than 96%.

As topology, a totem-pole PFC combined with an LLC stage has been chosen. This is equipped with CoolSiC™ for the fast-switching leg in the PFC, the CoolMOS™ 8 for the slow switching leg and the CoolMOS™ CFD7 for the DCDC stage.

Overall, a full system solution in a state-of-the-art form factor with high efficiency is achieved, along with a focus on balanced bill of material (BOM) cost over performance. With two XMC™ microcontrollers, the latest EiceDRIVER™, and power MOSFETs, Infineon combines the best of the latest product offerings.

3.3kW HF/HD Rectifier Reference Design (REF_3K3W_HFHD_PSU)



Technical details

PFC key requirements	Value
Input voltage range	180 V_{AC} ~ 275 V_{AC}
Output voltage range	51 - 48 V_{DC}
Output current nom	@51V=65A @50V=66A @48V=69A
Output power max	3300 W
Efficiency	~ 97,5 %
Power factor (load > 10%)	PF > 0.95 @ 180 ~ 275 V_{AC} iTHD < 10% @ 180 ~ 275 V_{AC}
Temperature Ambient	0°C to 50°C
Fsw. LLC	550kHz
Learn More	
Infineon components	4xIGT60R042D1, 4xIMT65R057M1H, 5x**IPT60R016CM8**, 1xIPT60R080G7, 1xIDL10G65C5, 1EDB8275F, 1EDN8511B, 2EDB9259Y, 1EDN8550B IQE046N08LM5, ICE2QR2280G, BAT46WJ, BAT165, BSS138N, TLS4120D0EPV33, 4DIR1400H,
Controller	XMC4200 PFC, Microchip for high frequency control LLC
Application	Industrial SMPS, Telecom Rectifier, Battery Charging

Features

- **Benchmark 97,5% of efficiency @ 95W/in³** including all /1U Formfactor
- Highest efficiency & power density with CoolMOS™ 8, CoolSiC™ , CoolGaN™ Novel integrated planar magnetic construction
- Full digital control (PFC and DCDC)
- Totem-Pole PFC + Half-Bridge GaN LLC

Benefits

- Full Infineon's semiconductor solution
- Complete Power Supply Unit (PSU) including PFC + DCDC
- High efficiency, propietary and integrated magnetics design
- Hold up time extension circuit

Figure 31 3.3 kW HF/HD rectifier reference design (order code: REF_3K3W_HFHD_PSU)

The 3.3 kW HF/HD Rectifier reference design benchmarks the highest efficiency and power density in a small form factor by combining the latest CoolMOS™, CoolSiC™, and CoolGaN™ products. It is a complete power supply system that includes a totem-pole PFC with CoolMOS™, CoolSiC™ and a CoolGaN™ LLC stage.

7 Summary

This document has described Infineon's latest high-voltage superjunction CoolMOS™ 8 600 V SJ MOSFET technology with the following key features:

- **Best–fit performance for target markets**
  - Attractive "all-in-one" SJ MOSFET technology for industrial and consumer applications
  - Enabling the reduction of switching losses
  - Lowest and best-in-class $R_{DS(on)}$ per package (7 mΩ in QDPAK, 16 mΩ in TO220 and TO247)
  - Enabling smaller form factors
  - New package innovations (e.g., ThinTOLL as a replacement for ThinPAK)
- **State-of-the-art in "ease-of-use"**
  - Enabling of usage of one SJ MOSFET family across all main topologies
  - Outstanding body diode ruggedness over full portfolio range
  - Excellent ESD robustness greater than 2 kV (HBM)
  - Low ringing tendency
- **Best-in-class commercial aspects**
  - Price performance leader
  - 19 parts in 9 different packages, more to come
  - $R_{DS(on)}$ granularity from 7 to 600 mΩ
  - Suitable for a wide variety of applications and power ranges

Through real application measurements, it has also been demonstrated that the CoolMOS™ 8 with a lower FOM enables improved efficiency over the CoolMOS™ 7 series.

On system level, CoolMOS™ 8 offers the highest performance in combination with CoolSiC™ or CoolGaN™.

This feature enables the design engineers to easily design their power converters with high efficiency, high power-density, robustness, and cool thermal behavior. Furthermore, CoolMOS™ CM8 is the best price/performance solution, providing a long-term perspective.

References

[1] **Webpages:**

- Infineon Technologies AG: *600 V CoolMOS™ 8 MOSFET;* Available online
- Infineon Technologies AG: *500V-950V CoolMOS™ N-Channel Power MOSFET*; Available online
- Infineon Technologies AG: *Evaluation board finder*; Available online

[2] **Additional application notes:**

- Infineon Technologies AG: *CoolMOS™ gate drive and switching dynamics*; Available online
- Infineon Technologies AG: *CoolMOS™ C7 650 V switch in Kelvin source configuration*; Available online
- Infineon Technologies AG: *Designing with power MOSFETs*; Available online
- Infineon Technologies AG: *Dynamic thermal behavior of MOSFETs;* Available online
- Infineon Technologies AG: *EiceDRIVER™ - Gate resistor for power devices;* Available online
- Infineon Technologies AG: *EiceDRIVER™ - Linear mode operation with high-voltage superjunction MOSFETs*; Available online
- Infineon Technologies AG: *Part I: LLC calculator*; Available online
- Infineon Technologies AG: *Part II: Using the LLC calculator with Rules of Thumb (ROT) and fast verification with LTspice*; Available online
- Infineon Technologies AG: *Optimizing CoolMOS™-based power supplies to meet EMI requirements*; Available online
- Infineon Technologies AG: *Thermal performance of surface mount semiconductor packages*; Available online
- Infineon Technologies AG: *From Electromechanical Relays to robust semiconductor solutions: Solid-State Relays with optimized superjunction FET technology*; Available online
- Infineon Technologies AG: *Some key facts about avalanche*; Available online

[3] **Training videos:**

- Infineon Technologies AG: *Top side cooling with high voltage packages*; Available online
- Infineon Technologies AG: *Si, SiC or GaN? The right choice for power devices;* Available online

Revision history

Document revision	Date	Description of changes
V 1.0	2024-05-06	Initial release

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Edition 2024-05-06

Published by

Infineon Technologies AG

81726 Munich, Germany

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Document reference

AN091456