CoolSiC™ MOSFET G2 650 V & 1200 V

Empowering the next generation of high-performance systems

Online media briefing

Dr. Peter Friedrichs

restricted

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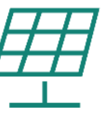
Striving for excellence in SiC MOSFETs by trench technology



CoolSiC™ Generation 1

- Established the benchmark in efficient power conversion
- Solved the gate oxide reliability risk in SiC MOSFETs using a trench gate
- Overcame common SiC MOSFET limitations in control and drive
- Made all industry-standard packages available

Reliable performance

CoolSiC™ Generation 2

- **Securing price-performance leap**
- **Maintaining G1 high reliability**
- **Adding new robustness features for** maximizing each $ invested in SiC-based power systems
- **Advancing the packaging technology** for more powerful products

Unmatched industry leadership

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CoolSiC™ MOSFETs entering a new era with G2

CoolSiC™ Generation 2

Feature	Benefit
Improved chip performance and FOMs	5~20% lower power losses over typical load use cases
Improved .XT package interconnect	12% better thermal resistance, $R_{th,j-c}$
Best-in-class $R_{DS(on)}$ and the most granular portfolio in the market	Single digit with G2 compared to G1 6.7mΩ 650V and 7.7mΩ 1200V
Enlarged maximum gate-source voltage -10 V to +23 V	Serves all the SiC applications without any compromise in design flexibility
Overload operation up to Tvj = 200°C and avalanche robustness	Simplifies system design for over-current events, e.g. grid fluctuations (1200 V)
Robust **short-circuit** rating	2 µs guaranteed withstand time (1200V)
High reliability	Maintaining G1 proven level, very low DPM rates

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CoolSiC™ G2: a new level of performance in full-load operation

Hard-switching	Soft switching
	with LLC or CLLC topology

Hard-switching: G1 vs G2 — -10%

Conduction losses / Switching losses

Total power loss reduction for better energy efficiency and cooling optimization

Soft switching: G1 vs G2 — -5%

Conduction losses / Switching losses

Application conditions with G1 (IMBG120R030M1H) and G2 (IMBG120R026M2H):
DC-AC inverter or AFE stage. I_{RMS} = 20 A, f_{sw} = 40 kHz, R_G = 10 Ω, T_{vj}= 100°C. dead time = 200ns

Application conditions with G1 (IMBG120R030M1H) and G2 (IMBG120R026M2H):
DC-DC stage, I_{RMS} = 20 A, f_{sw} = 100 kHz, R_G = 10 Ω,, T_{vj}= 100°C, dead time = 200 ns, soft-switching operation

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CoolSiC™ G2 in light-load condition: significant improvement of power losses

-20%

	Conduction losses	Switching losses
G1		
G2		

Total power losses reduced by improved switching performance

Application conditions: DC-AC inverter or AFE stage with G1 (IMBG120R030M1H) and G2 (IMBG120R026M2H). I_{RMS} = 5 A, f_{sw} = 40 kHz, R_G = 10 Ω. T_{vj}= 100°C, dead time = 200ns

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Enhancement of thermal capabilities in small package form factor

- New chip technology means heat concentrated to a smaller area
- Innovative chip technology needs innovative interconnection
- **CoolSiC™ G2 comes with improved .XT technology**

CoolSiC™ .XT

$R_{th,j\text{-}c,max}$ [K/W]

-12% better

G1 .XT G2 .XT

Loss dissipation capability [W]

G1 .XT G2 .XT

>14% extra loss can be dissipated

- 6-7% extra current
- ~5 K lower temperature
- up to 50% increase in f_{sw}

Comparison is made with G1 and G1 products having equal $R_{DS(on)}$ at T_{vj}= 100 °C.

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Raising the bar for the power possible in SMD

- CoolSiC™ G2 trench technology in combination with .XT interconnect enables an **8 mΩ rated 1200V SiC MOSFET in D2PAK-7 package**
- The highest output capability in D2PAK-7 form factor enables higher system power or reduced paralleling of devices

*Status January 2024, based on datasheet comparison 1200 V SiC MOSFETs in the internet: IMBG120R008M2H versus NTBG014N120M3P. Calculation based on conduction losses, I_D @ 90°C IMS, R_{th_IMS}= 1 K/W, 800 V DC bus

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CoolSiC^{TM} – another great example for Infineon‘s Quality Leadership

dpm – defects per million for GIP SiC products

Data based on G1 SiC power switches sold

- Infineon‘s SiC power switches never caused any „spill“ or severe incident on customer side
- The product returns for SiC are even below silicon-based power switches, a very mature technology
- This counts for discrete devices as well as for power modules
- Infineon‘s CoolSiC^{TM} provides the same or even better quality level as silicon to our customers

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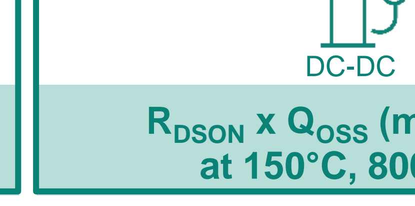
Unveiling a new performance budget with CoolSiC™ G2

Figures-of-merit (FOM) comparison: lower is better for energy efficiency optimization

R_{DSON} x Q_{GD} (mΩ*µC) at 150°C, 800 V, 28 A:



R_{DSON} x Q_{OSS} (mΩ*µC) at 150°C, 800 V:

R_{DSON} x E_{OSS}(mΩ*µJ) at 150°C, 800 V:

The classical MOSFET FOM (from low-voltage silicon world)

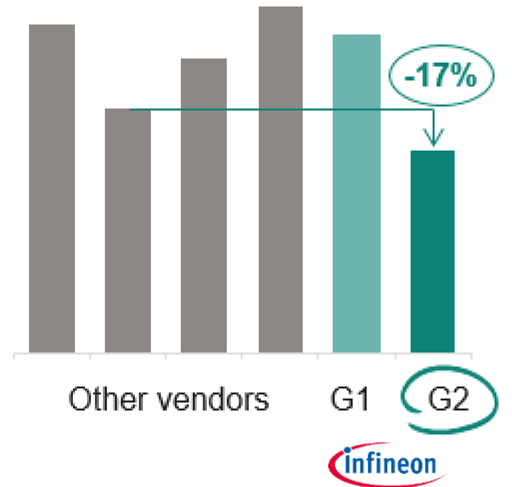
R_{DS} x Q_G (mΩ*µC) at 150°C:

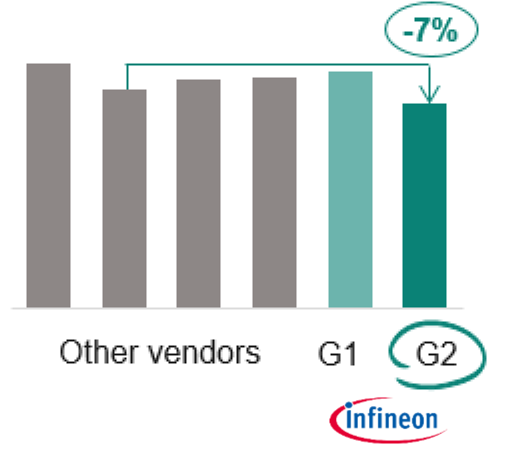
Lower is better in hard-switching topologies

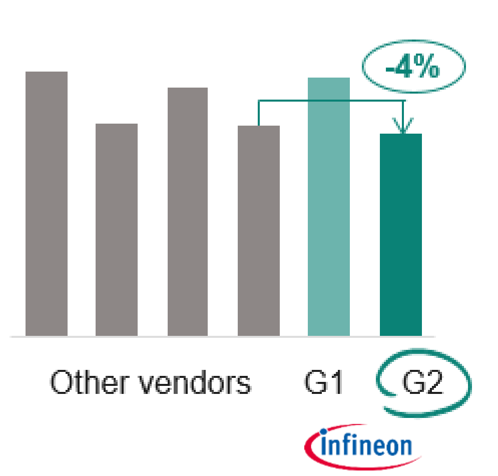
Lower is better in soft-switching topologies

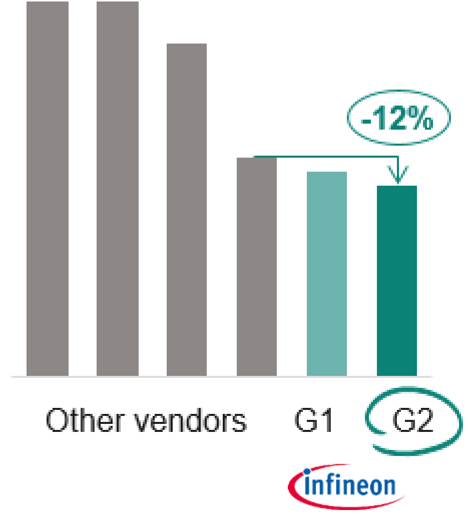
Lower is better for light-load efficiency

Lower means lower gate driving power loss









Infineon products: IMBG120R030M1H, IMBG120R026M2H.
Other SiC MOSFETs: value of parameters taken from datasheet in internet for the latest generations of 1200 V SiC MOSFETs in D2PAK 7pin: C3M0032120J1, SCT4018KW7, NTBG030N120M3S, SCT025H120G3AG,
Q_{GD} = total charge associated to C_{RSS} at given conditions, Q_{oss}= total charge associated to C_{OSS} at given conditions. E_{OSS} = total energy associated to C_{OSS} at given conditions

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CoolSiC overall portfolio offering

package options / voltages	Industrial grade							Automotive grade					
	CoolSiC™ Diode	CoolSiC™ Hybrid		CoolSiC™ MOSFET				CoolSiC™ Diode	CoolSiC™ Hybrid	CoolSiC™ MOSFET			
	Discrete	Discrete	Module	Discrete	IPM	Module	HP Module	Discrete	Discrete	Discrete	Module		
400V													
600 V													
650 V													
750 V													
1200 V													
1700 V													
2000 V													
3300 V													

Continuous extension of portfolio

Industrial grade legend: G1 mass production | G1 coming soon | G2 mass production | G2 coming soon

Automotive grade legend: G1 mass production | G1 coming soon | G2 mass production | G2 coming soon

Status: March 2024

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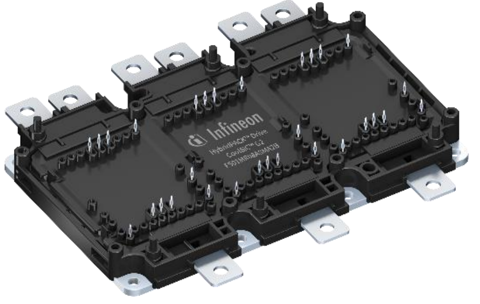
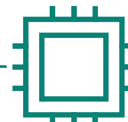
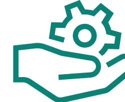
CoolSiC™ G2 ON THE ROAD!

SAIC launched IM LS6 with 2nd generation of CoolSiC™ HybridPACK™





- **2nd generation CoolSiC™** HybridPACK™ Drive FS02
- AURIX™ TC389 MCU
- Power supply TLF35584
- LV MOSFET IPDxx



- **One Inverter One Infineon:** one stop shop for all Inverter semi component
- **Best power scalability** in the market, easy platform migration and less design-in effort

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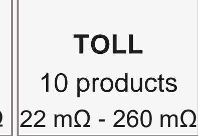
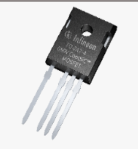
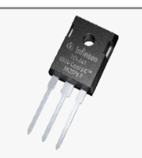
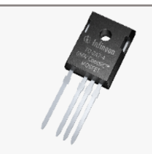
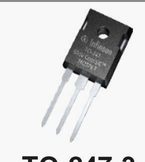
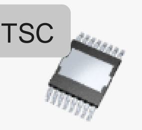
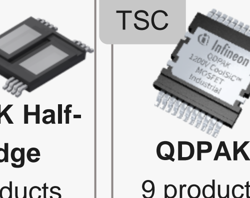
Near-term roll-out of CoolSiC™ MOSFET G2 discretes industrial grade: 400 V, 650 V and 1200 V





	CoolSiC™ G1	CoolSiC™ G2 wave 1	CoolSiC™ G2 coming soon in 2024-2025
400 V		**TOLL** 5 products ~11 mΩ - ~43mΩ	**D²PAK-7** 5 products ~11 mΩ - ~43 mΩ
650 V	**TO-247-4** 8 products 27 mΩ - 107 mΩ **TO-247-3** 8 products 27 mΩ - 107 mΩ **D²PAK-7** 11 products 9 mΩ - 260 mΩ **TOLL** 10 products 22 mΩ - 260 mΩ	**D²PAK-7** 5 products 7 mΩ - 50 mΩ **TO-247-4** 4 products 7 mΩ - 50 mΩ **TO-247-3** 4 products 7 mΩ – 50 mΩ	**TO-247-4** 6 products 7 mΩ - 50 mΩ **TO-247-3** 6 products 7 mΩ – 50 mΩ TSC **TOLT** 7 products 15 mΩ - 60 mΩ TSC **ThinTOLL 8x8** 4 products 20mΩ - 60 mΩ
1200 V	**TO-247-4** 10 products 7mΩ - 350 mΩ **TO-247-3** 10 products 7mΩ - 350 mΩ **D²PAK-7** 7 products 30 mΩ - 350 mΩ	**D²PAK-7** 12 products 8 mΩ - 234 mΩ	**TO-247-4** 9 products 7 mΩ - 79 mΩ TSC **QDPAK Half-bridge** 4 products 12 mΩ - 53 mΩ TSC **QDPAK** 9 products 4 mΩ - 53 mΩ

and more

TSC= Top Side Cooling

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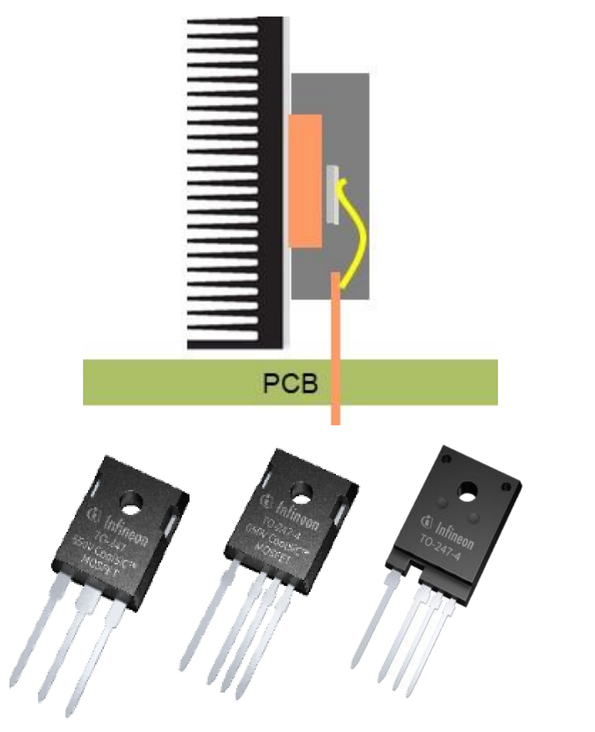
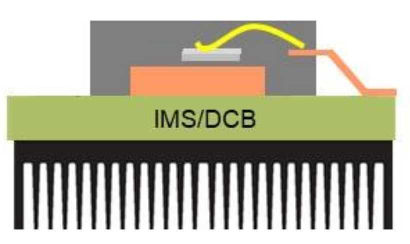
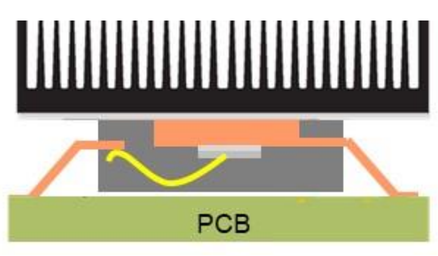
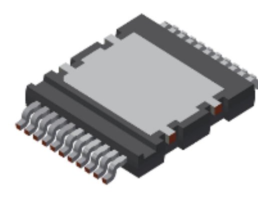
Package evolution which enables high volume assembly and PCB design improvement at expensive assembly location









THD – Through Hole Device	SMD Bottom-side cooling	SMD top-side cooling
– Robust thermal performance	– Medium thermal performance	– **Optimal** thermal performance
– Manual handling	– Fully automatic handling	– **Fully automatic** handling
– Low pin count, improved with 4-pin variant	– High pin count	– **High** pin count

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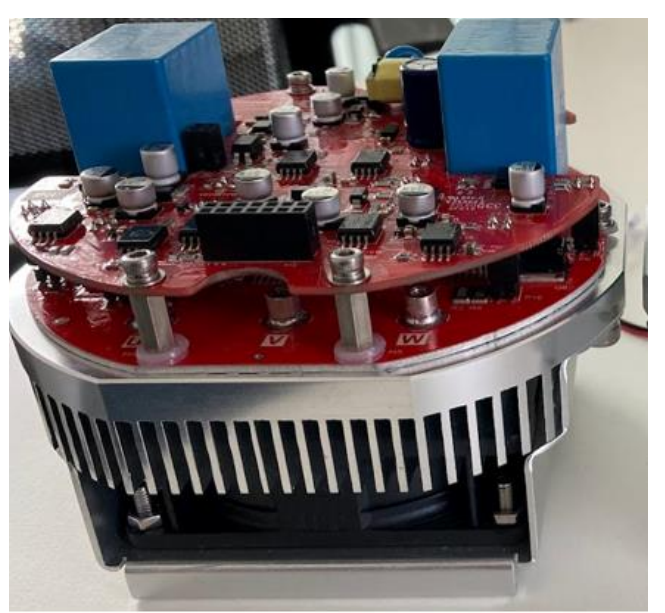
Significant production cost reduction with simplified design
1.2 kV SiC Servo Motor Drive Demonstrator

Standard cooling assembly

Stack: FR4 + IMS +

- IMS board used for power components
- FR4 PCB used for IC/driver/magnetics components



Top-side cooling assembly

Stack: FR4 +

IMS board eliminated

- Single FR4 PCB used on both sides for **all** power components
- Reduced stray inductance

- 65% Rth

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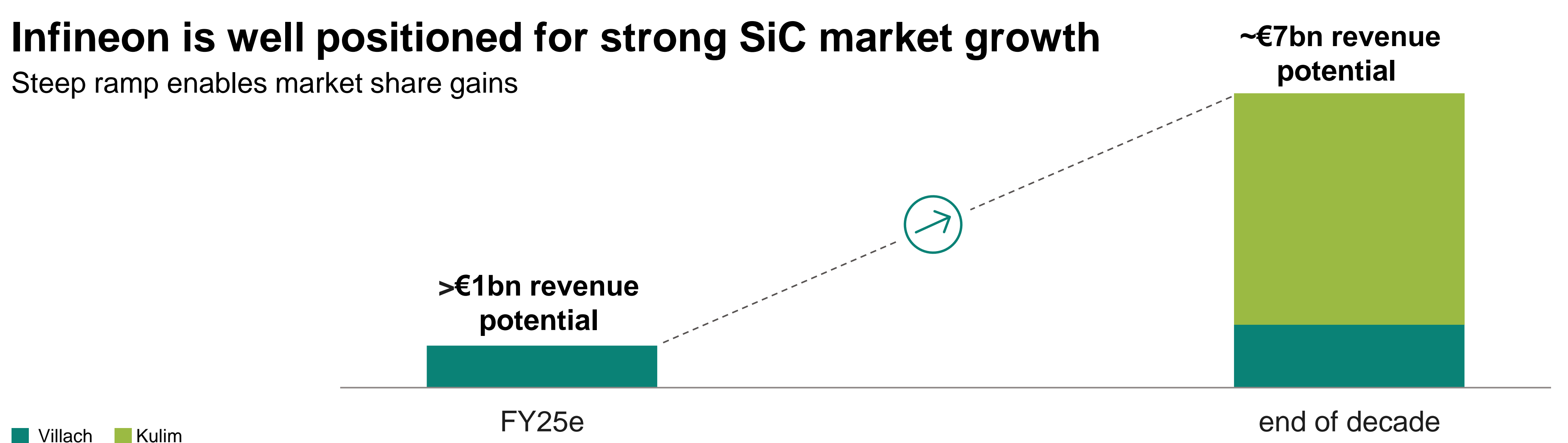
Market share target in SiC by end of decade underpinned by significant capacity expansion

Infineon is well positioned for strong SiC market growth

Steep ramp enables market share gains



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Building the world's largest 200-millimeter SiC power fab

Rationale

- **Undisputed leadership** position in power systems across **all materials** based on technology and scale
- Expanding the third module at the existing site in Kulim offers significant advantages – **economies of scale, competitive local cost position, implementation speed** and reliability from existing employees and infrastructure
- **Modular setup** allows for flexibility in ramp-up phase

Kulim 3 phase 2 investment	**up to €5bn**
Related design-wins	**~ €5bn**
Customer pre-payments	**~ €1bn**
Start of production	**Summer 2027**

Total SiC revenue potential[1] end of decade: ~ €7bn

Phase 2

Phase 1

1 Total revenue potential comprises Villach, Kulim 3 phase 1 and phase 2 incl. 200-millimeter conversion

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Wide-Bandgap Developer Forum 2024

16 April 2024, 8 am CEST
Full-day virtual event

10 am – 10:30 am CET
CoolSiC™ trench MOSFETs the next generation – new levels of system performance on the horizon

Dr. Peter Friedrichs, Vice President SiC

10:30 am – 11:00 am CET
Guest speaker: Wide-Bandgap semiconductors and applied use cases in future e-drive train

Jian Wang, Executive director of SMPV & head of SAIC E-propulsion group

Register for free

Questions & answers

Please place your questions into Slido in Webex for the Q&A session.

Slido QR code

www.infineon.com/coolsic-g2