

# CoolSiC™ 2 kV – new horizons with leading edge technology

December 2023

restricted

# SiC will add significant value to a broad variety of systems across many applications

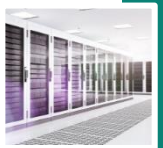




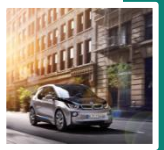
**Photovoltaic**
- reduction of system cost
- reduction of system size



**EV charging**
- 30 to 50% faster charging cycles
- ~2% higher efficiency



**Industrial power supplies/ UPS**
- higher efficiency
- reduced total cost of ownership



**eMobility**
- higher reach per charge
- more compact main inverter



**Traction**
- energy savings of ~10%
- reduction of motor noise



**Drives**
- reduced system size
- enable passive cooling



**Energy storage system**
- higher efficiency (extra energy of ~2% at same battery size)



**Commercial HVAC**
- higher efficiency, reduced system size
- reduction of noise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# Accelerating the mobility transition through state-of-the art charging infrastructure powered by CoolSiC™ products



- Fastest charging cycles
- More compact designs with up to +30% power density
- Highest lifetime and reliability
- Innovative use cases

**Controller**

AURIX™ microcontroller



**EiceDRIVER™ gate driver ICs**

EiceDRIVER™ enhanced



**CoolSiC™ switches**

650 V/ 1200 V CoolSiC™ MOSFETs





1200 V in EasyPACK™






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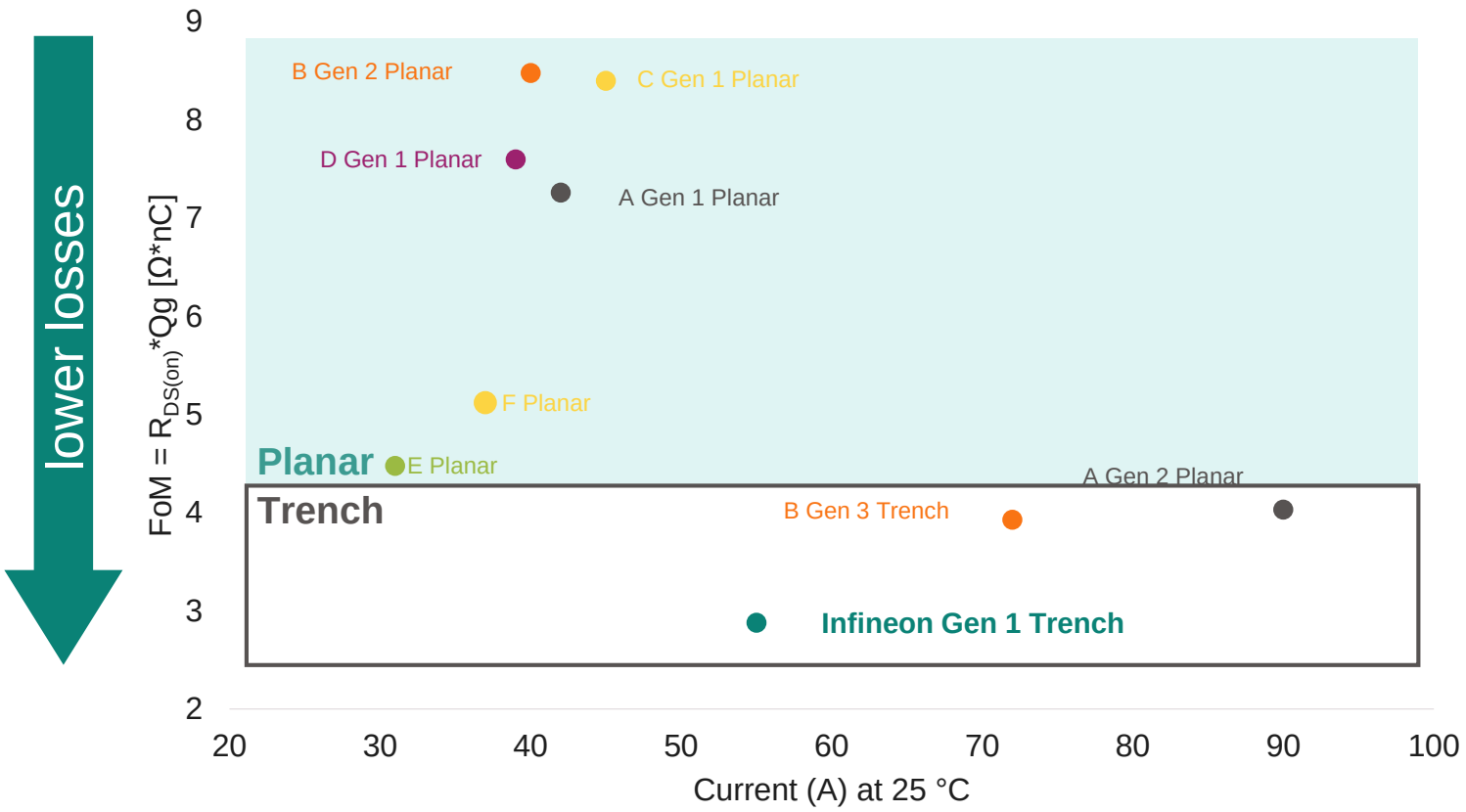
# Second generation (2nd Gen.) CoolSiC™ trench MOSFET will increase the addressable market

## 1st Gen. with lowest losses is the leading technology today




## 2nd Gen. will expand the lead

- 2nd Gen. CoolSiC™ trench MOSFET is in advanced development phase
- Enhanced power handling capability by 25% – 30%
- Enhanced safe operating area without compromising quality
- Enabling SiC in further high volume applications

**2nd Gen. CoolSiC™ Trench MOSFET will significantly enlarge the market size for SiC MOSFETs**

Source: SystemPlus Consulting: SiC Transistor Comparison 2020. November 2020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# The 2 kV SiC technology brings additional power density increase and leads to system cost reduction

## 2 kV brings power density increase




SiC



SiC

Courtesy: Kaco and pv magazine

| | 2008 | 2011 | 2016 | 2018 | | 2022 |
|---|---|---|---|---|---|---|
| | 100 kW<br>1129 kg | 50 kW<br>151 kg | 50 kW<br>70 kg | 125 kW<br>77 kg | | **2 kV** |
| kW/kg | 0,09 | 0,33 | 0,7 | 1,6 | → | **> 2** |

## Additional benefits using 2 kV CoolSiC™

- Realization of higher system voltage
- Simplification of designs
- System cost reduction
- High efficiency & high reliability
- Ready for emerging use-cases



1500 V in photovoltaic



~1500 V energy storage



1500 V charging in the future



Solid-state transformer


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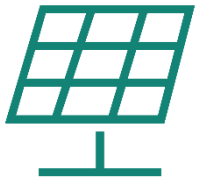
# Increasing power with half the part count

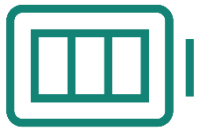
**High voltage new trend up to 1500 V DC:**



Solar

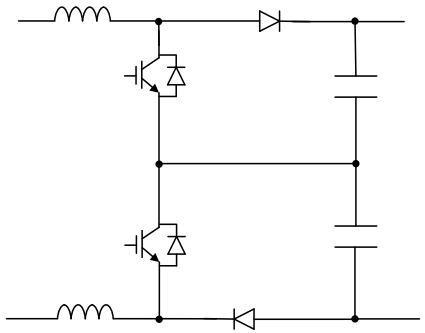



High power charger

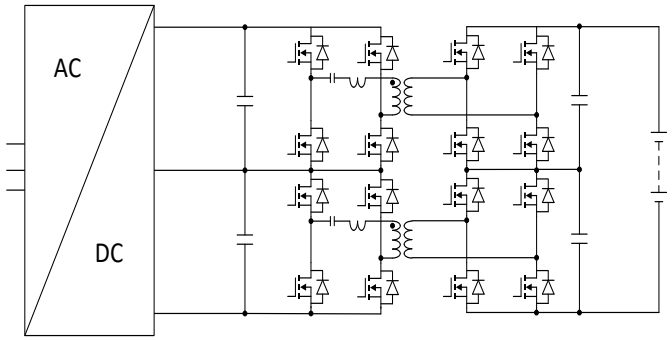


Storage

## Technical barrier with 1200 V devices

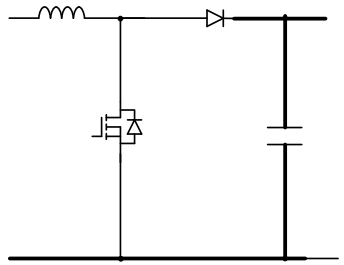


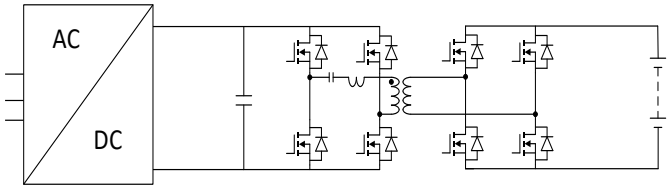
... or other complicated multi-level topologies




**No viable Si solution**, even 1.2 kV SiC gets complicated...

## 2 kV SiC solution







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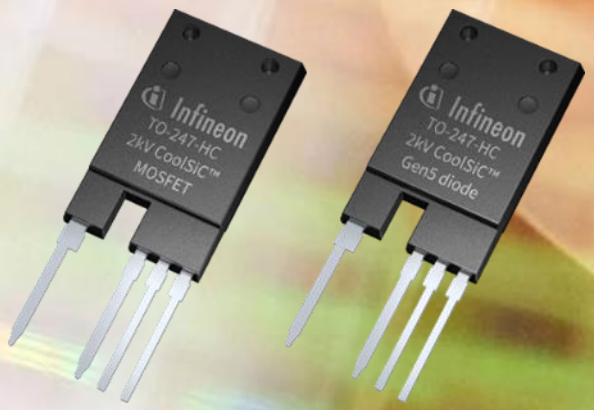
# True 2 kV SiC MOSFET & diode technology for applications operating up to 1500 V DC

- Technology designed to have both low $R_{DS(on)*}A$ and low FiT rate at 1500 V DC
- Base technology has passed all relevant qualification tests
- The latest CoolSiC™ technology gives full freedom in choosing the gate voltage during turn-off
- New package with higher creepage and clearance distance for this new voltage class





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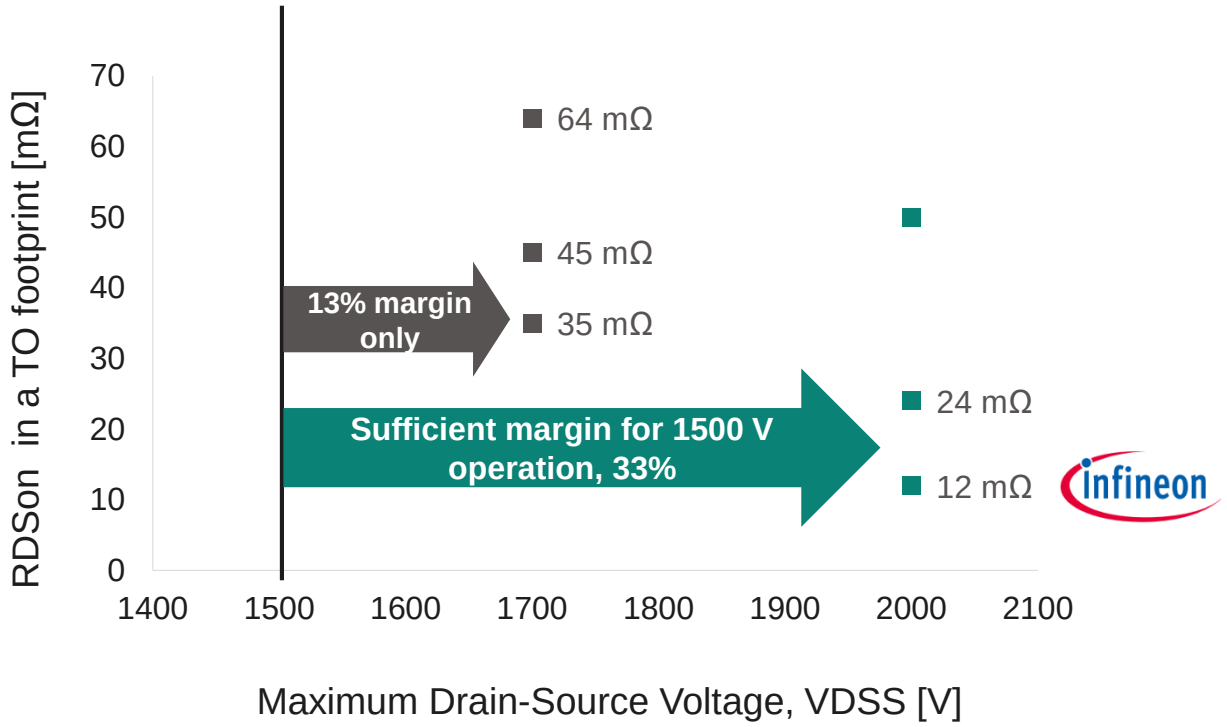
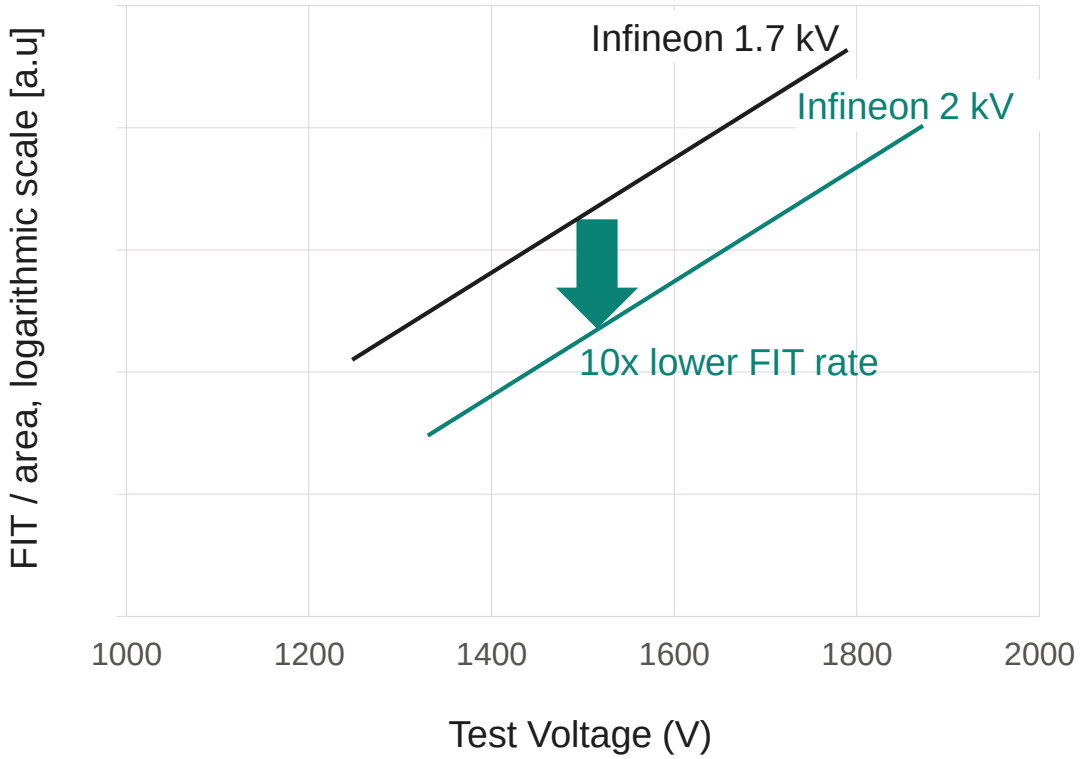
# No more pain with powering systems from 1500 V DC: 2 kV CoolSiC™ creates a new benchmark in power density

## Comparison of 1700-2000 V SiC MOSFETs*




## Cosmic Ray induced failure rate**




*Infineon reverse engineering of 1700 V SiC MOSFETs available in the open market :
fhttps://assets.wolfspeed.com/uploads/2020/12/C2M0045170D.pd
https://www.st.com/en/power-transistors/sct20n170.html
https://ww1.microchip.com/downloads/en/DeviceDoc/Microsemi_MSC035SMA170B4_SiC_MOSFET_Datasheet_A.PDF

**Infineon's own test results, shown value based on sea level, room temperature conditions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# Base technology has passed all relevant qualification test, especially these extended 2 kV relevant tests

| Test | Test conditions | Serial release: stress time |
|---|---|---|
| HTRB | $V_{DS}$ = **1800 V**<br>T = Tvjop_max | 1000 h |
| HTGS | $V_{DS}$ = 0 V<br>$V_{GS}$ = +23 V/-20 V<br>T = Tvjop_max | 1000 h |
| HV-H3TRB | $V_{DS}$ = **1600 V**<br>T = **85°C**<br>Relative humidity = **85%** | 1000 h |
| Dynamic H3TRB | $V_{DS}$ = pulsed voltage<br>T = 85°C<br>Relative humidity = 85% | 1000 h |

Long-term stability test at voltage level associated to 2 kV

Full humidity robustness according to harsh environment condition


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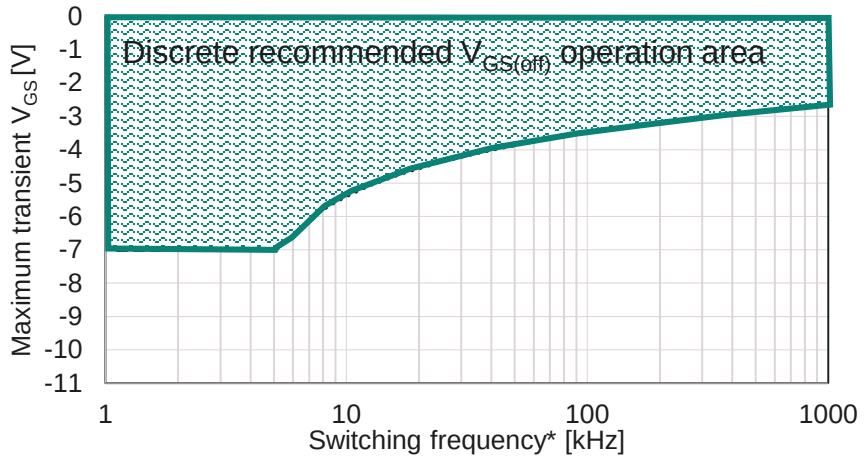
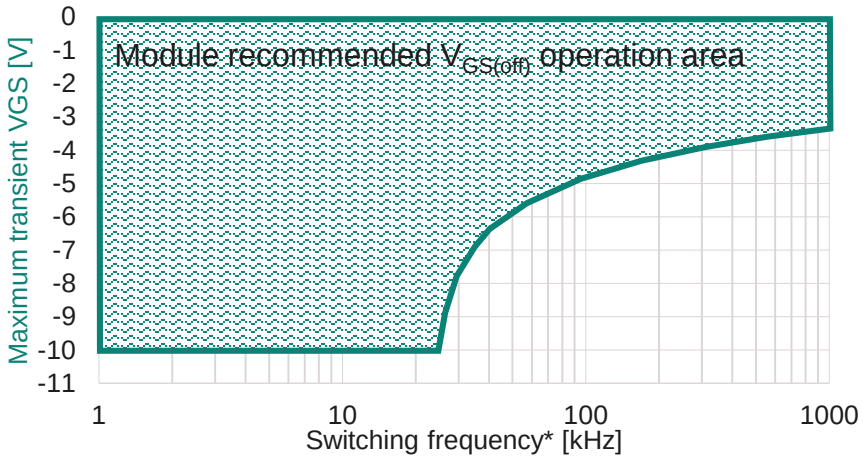
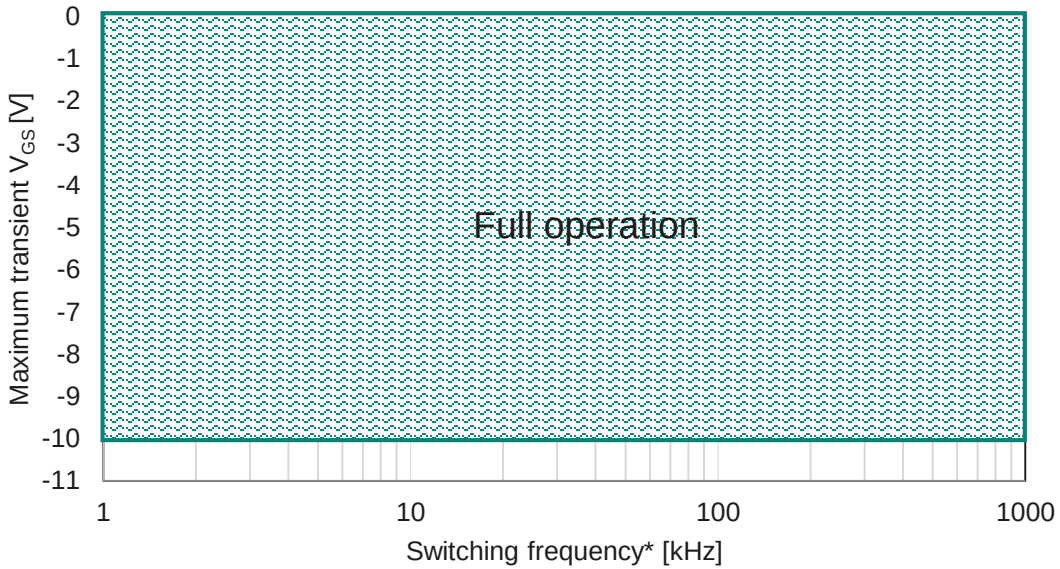
# In addition to 2 kV voltage, the latest CoolSiC™ base technology advancements gives full freedom in choosing the gate voltage

## Previous gate voltage recommendation area




## New gate voltage recommendation area




Ease of use with maximum negative gate-source voltage down to -10 V

*Assuming 10 years of continuous operation. For more details see Application Note AN2018-09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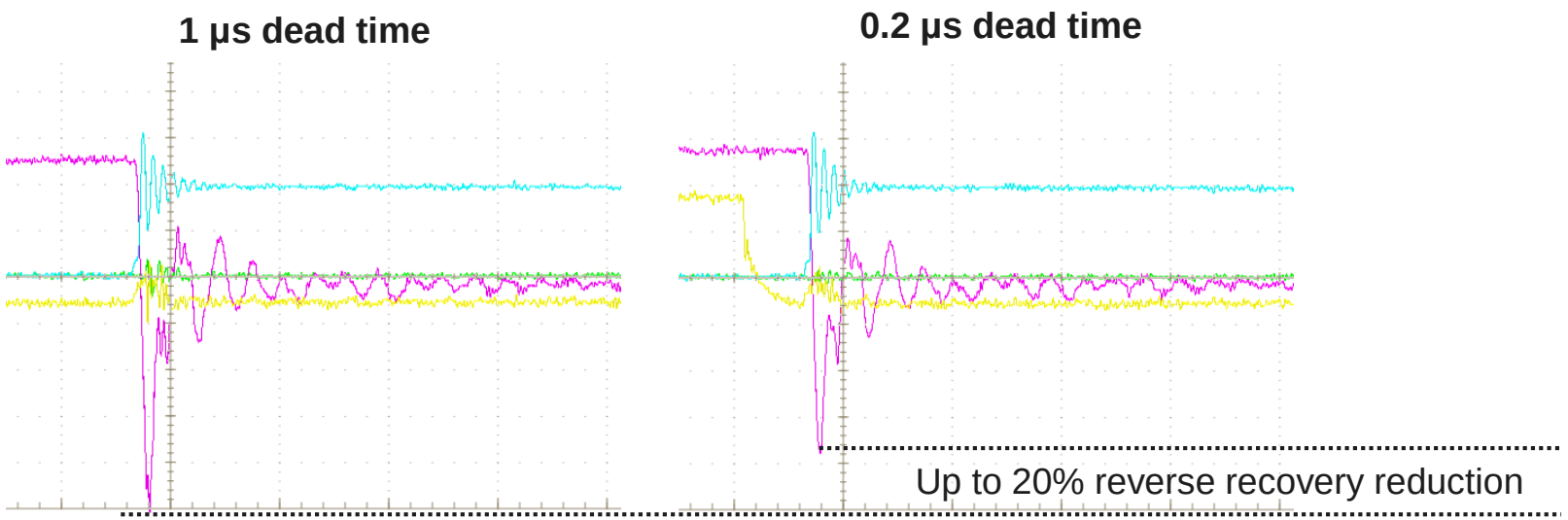
# 2 kV CoolSiC™ MOSFET needs no extra anti-paralleling free-wheeling diode

**The MOSFET body diode is robust against hard communication**

## Tip for enhancing body diode performance




Reducing dead time in hard switching condition will

→ **Reduce $E_{on}$ loss**

→ **Reduce EMI**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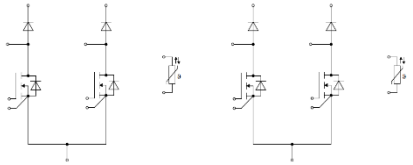
# 2 kV CoolSiC™ portfolio





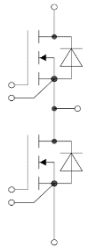
- EasyPACK™ package
- Four channel boost configuration with 2 kV SiC MOSFET and 2 kV SiC diodes
  - $R_{DS(on)}$ of MOSFET @ 25°C: 19 mOhm / channel
  - Current rating of diode: 40 A / channel

- Target application: MPPT of 1500 V PV string inverter

- Samples: available now
- Start of production: Q3 2022

| $R_{DSon}$ [mOhm] | Product |
|---|---|
| 19 | DF4-19MR20W3M1HF_B11 |





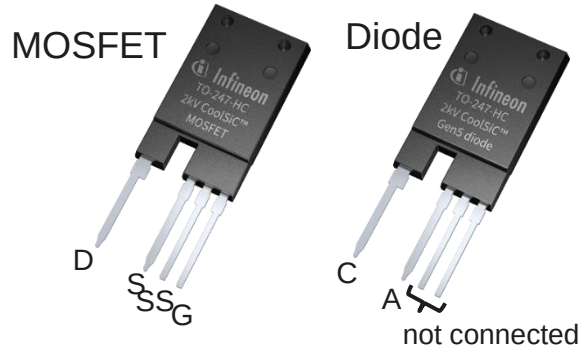
- 62 mm package
- Half-bridge configuration

- Target application:
  - Aux. Traction Converter
  - EV Charging
  - Energy Storage
  - Circuit Breaker

- Samples: available now
- Start of production: Q4 2022

| $R_{DSon}$ [mOhm] | Product |
|---|---|
| 3 | FF3MR20KM1H* |
| 4 | FF4MR20KM1H* |
| 6 | FF6MR20KM1H* |

- Will be available with TIM, indicated by P at the end
- Will be available as common source configuraiton, indicated by _S at the end




- New 2 kV package in a TO247-PLUS body
  - 14 mm creepage
  - 5.5 mm clearance distance
  - Utilizing the award-winning* latest .XT interconnection technology

- Target application:
  - PV
  - EV Charging
  - Energy Storage
  - Circuit Breaker

- Coming end of 2022

*https://www.der-deutsche-innovationspreis.de/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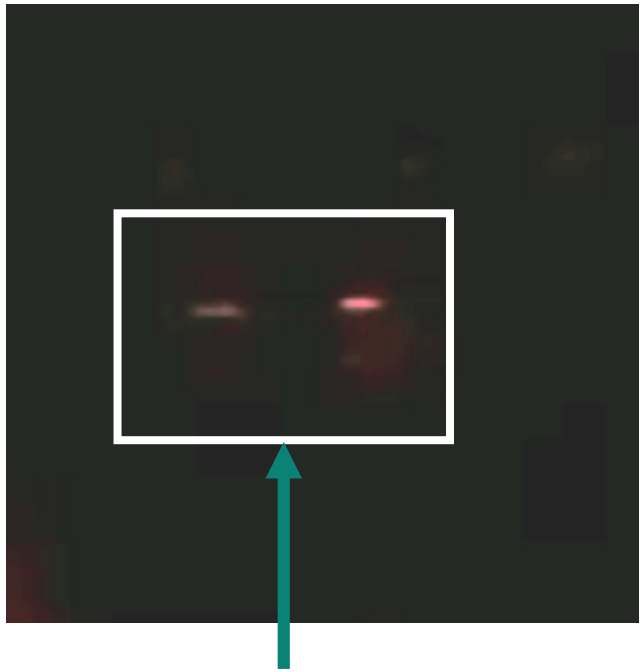
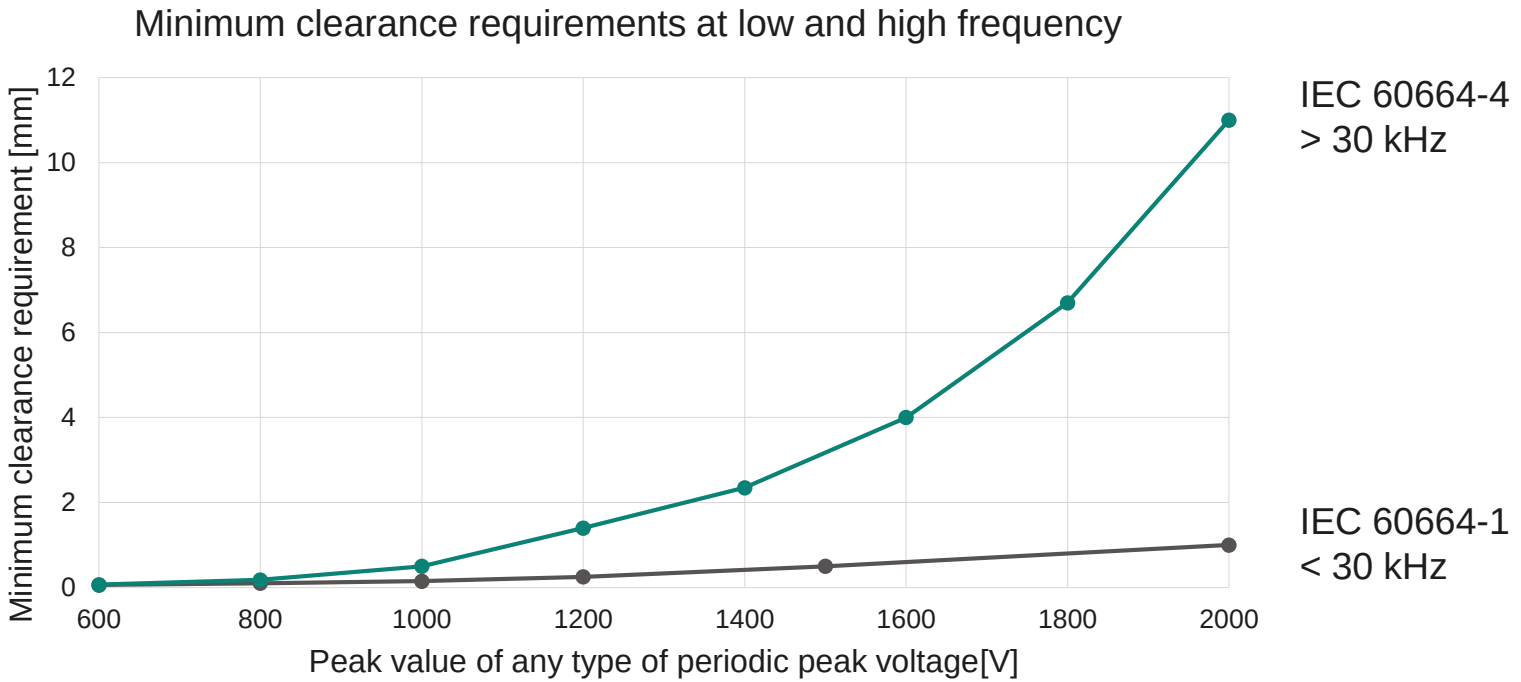
# Higher voltage in combination with higher frequency requires much higher clearance



**Corona high frequency discharge**

| | |
|---|---|
| Test conditions: | TO247 3 pin |
| Clearance distance: | ~ 2,6 mm |
| Continuous turn off voltage spike: | ~ 1,6 kV |
| Switching freq.: | ~ 80 kHz |




Clearance distance requirement is much higher with higher switching frequency

Extra care needs to be considered in system design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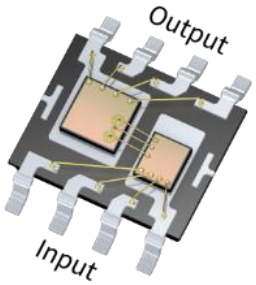
# EiceDRIVER™ isolated gate driver portfolio – The perfect match to support 2 kV CoolSiC™ MOSFET discrete and module

- Feature-set fully **SiC-ready**
  - Supports power switches **up to 2300 V**
  - **Strong** driving capability (18 A)
  - **Fast & accurate** timing (7 ns)
  - CMTI **robustness** (300 kV/µs)
  - **Enhances safety –** UL 1577 & **VDE 0884-11 certificates**

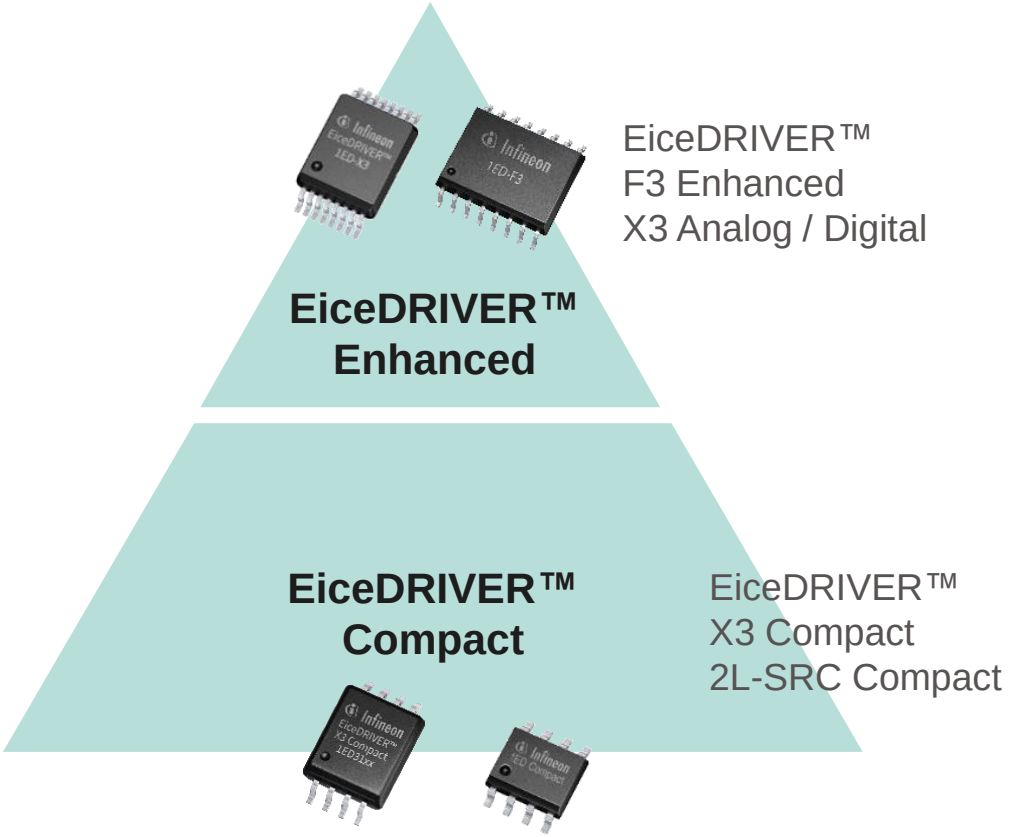
- EiceDRIVER™ Compact
  - **Miller clamp** for CoolSiC™ to avoid parasitic turn-on

- EiceDRIVER™ Enhanced
  - Provides **reliable & accurate short-circuit protection** for **CoolSiC™**
  - Improves **system reliability –** built-in **monitoring functionality**




Coreless Transformer technology

Source: Infineon US




Isolated gate driver sample box: KIT_GD_ISO_SAMPLE (available @ ISAR)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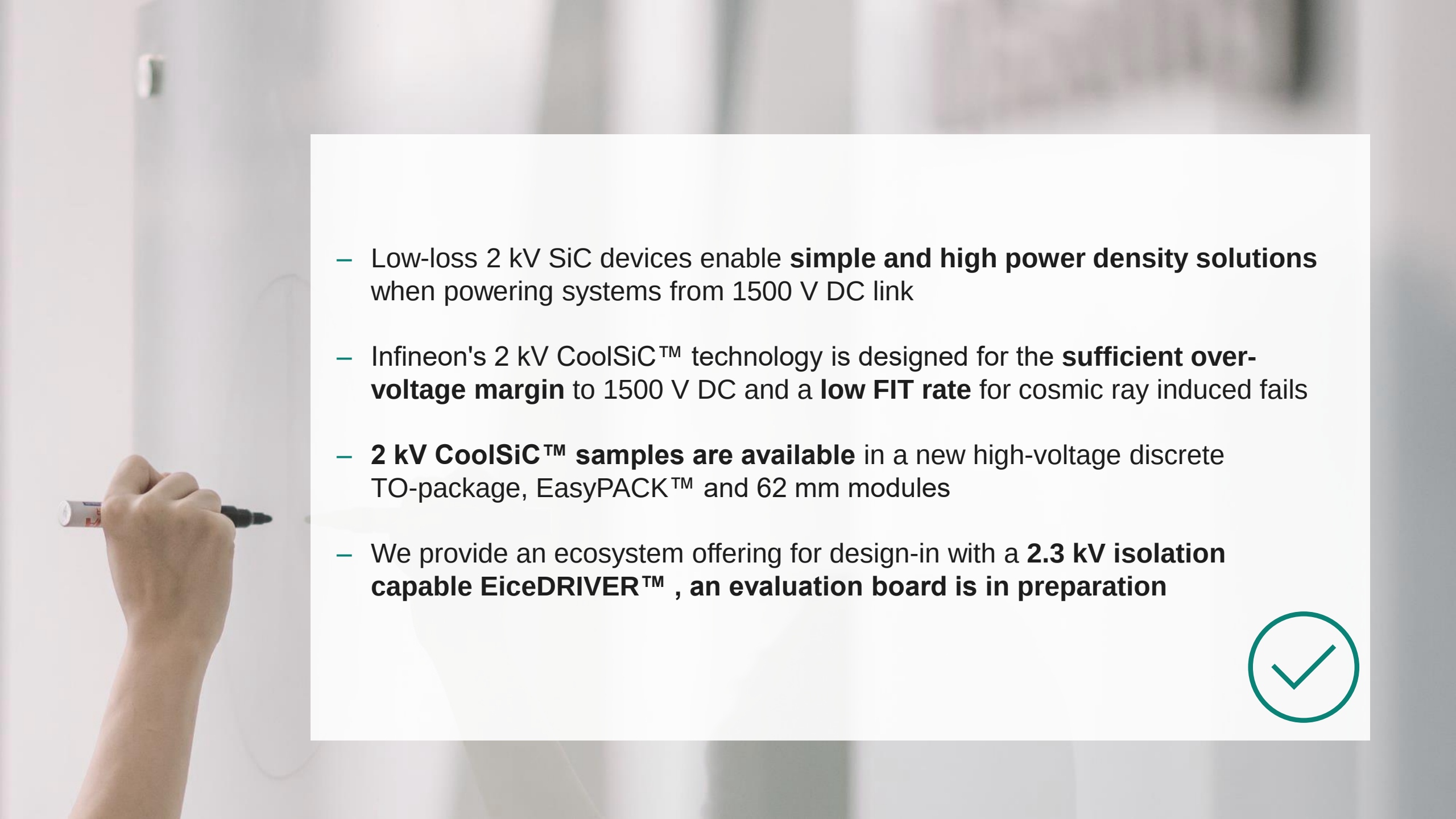

- Low-loss 2 kV SiC devices enable **simple and high power density solutions** when powering systems from 1500 V DC link
- Infineon's 2 kV CoolSiC™ technology is designed for the **sufficient over-voltage margin** to 1500 V DC and a **low FIT rate** for cosmic ray induced fails
- **2 kV CoolSiC™ samples are available** in a new high-voltage discrete TO-package, EasyPACK™ and 62 mm modules
- We provide an ecosystem offering for design-in with a **2.3 kV isolation capable EiceDRIVER™ , an evaluation board is in preparation**


Infineon