CoolSiC™

CoolSiC™ 2 kV – new horizons with leading edge technology

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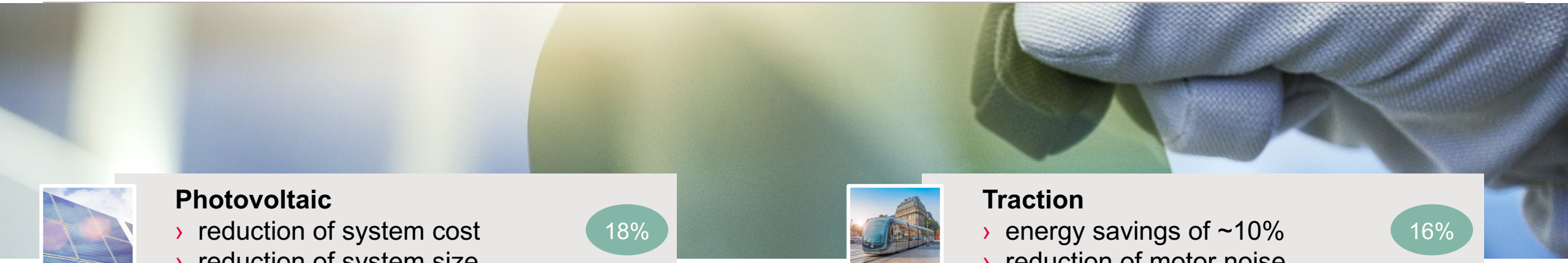
PCIM Europe 2022

Infineon

SiC adds significant value to a broad variety of systems across many applications resulting in high forecasted growth rates



Photovoltaic
› reduction of system cost
› reduction of system size

18%

EV charging
› faster charging cycles

24%

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

17%

eMobility
› higher reach per charge
› more compact main inverter

39%

tipping point reached

CAGR21-27

Traction
› energy savings of ~10%
› reduction of motor noise

16%

Drives
› reduced system size
› reduced total cost of ownership

43%

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

Commercial HVAC
› higher efficiency, reduced system size
› reduction of noise

future tipping points

Source: Yole Développement (Yole): Power SiC: Materials, Devices and Applications report, 2020

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

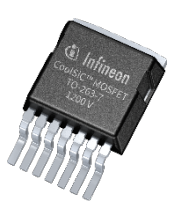
AURIX™ microcontroller

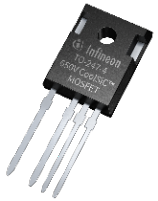
EiceDRIVER™ gate driver ICs

EiceDRIVER™ enhanced

CoolSiC™ switches

650 V/ 1200 V CoolSiC™ MOSFETs

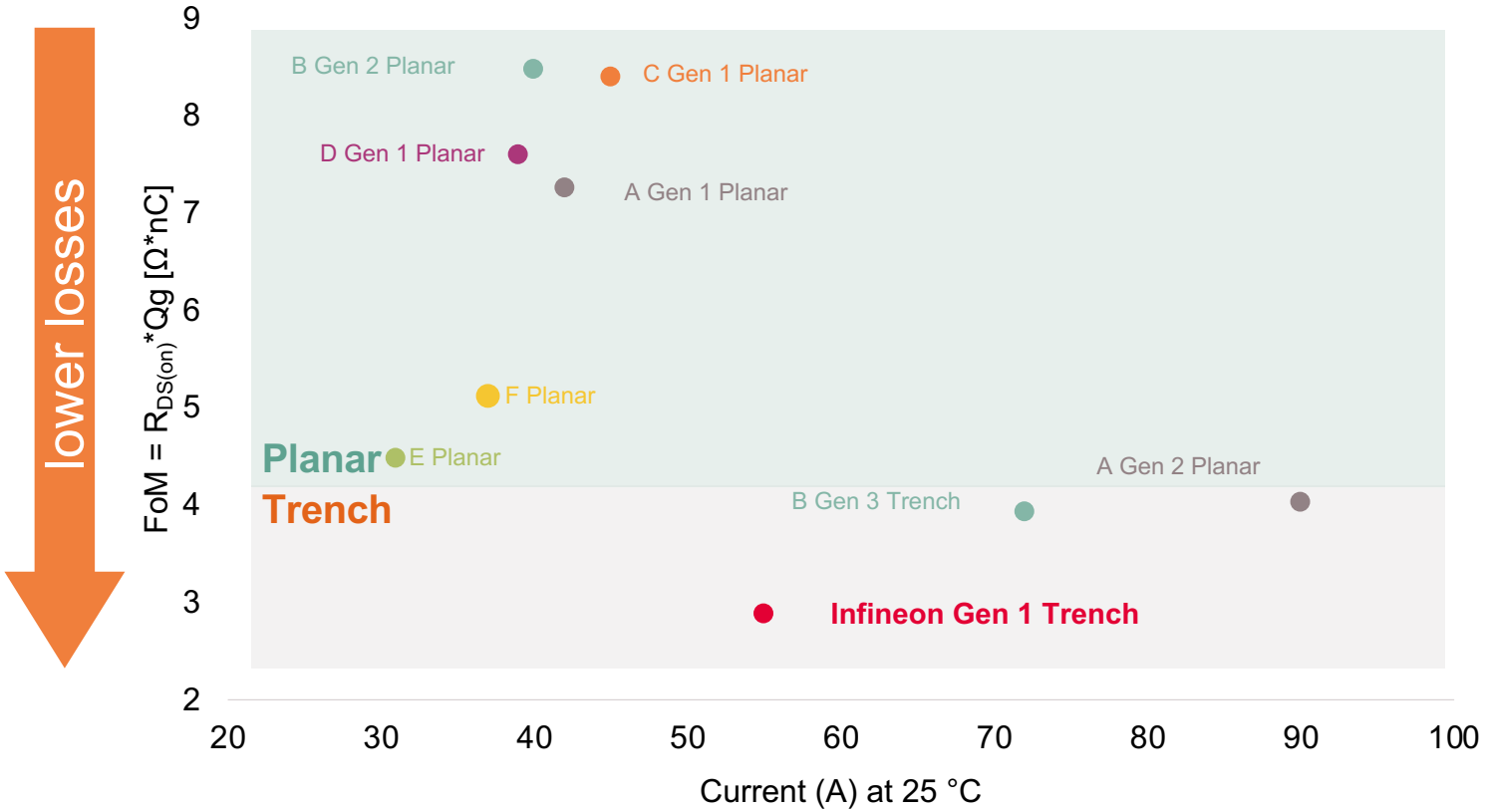




1200 V in EasyPACK™

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

The 2 kV SiC technology brings additional power density increase and leads to system cost reduction

2 kV brings power density increase

Courtesy: Kaco and pv magazine

2008	**2011**	**2016**	**2018**		**2022**
100 kW 1129 kg	50 kW 151 kg	50 kW 70 kg	125 kW 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

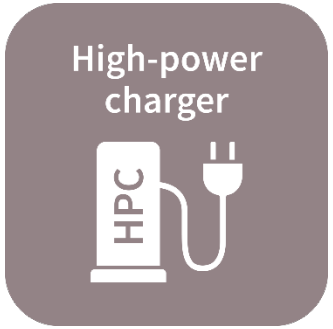

~1500 V energy storage


1500 V charging in the future

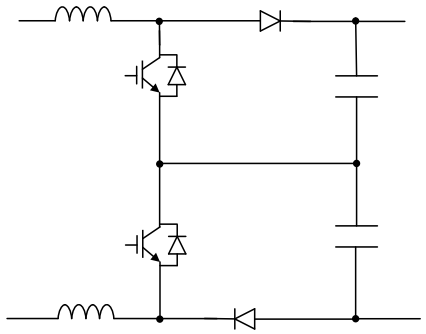

Solid-state transformer

Increasing power with half the part count

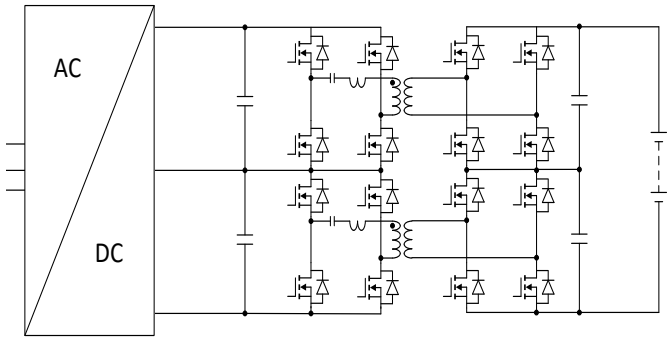
High voltage new trend up to 1500 V DC:



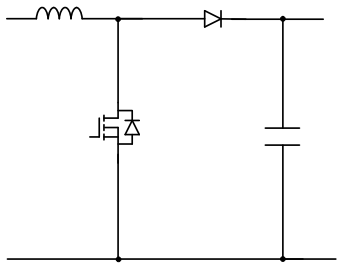
Technical barrier with 1200 V devices

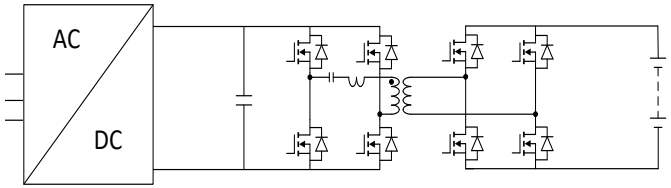


... or other complicated multi-level topologies



2 kV SiC solution

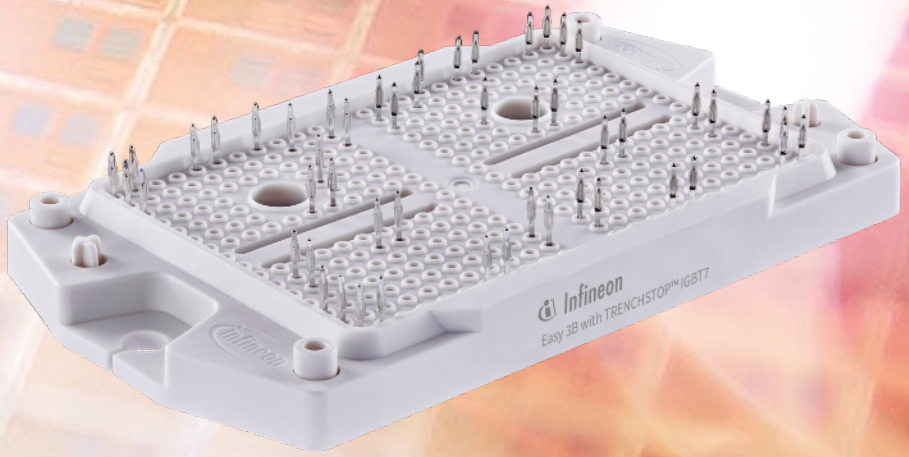


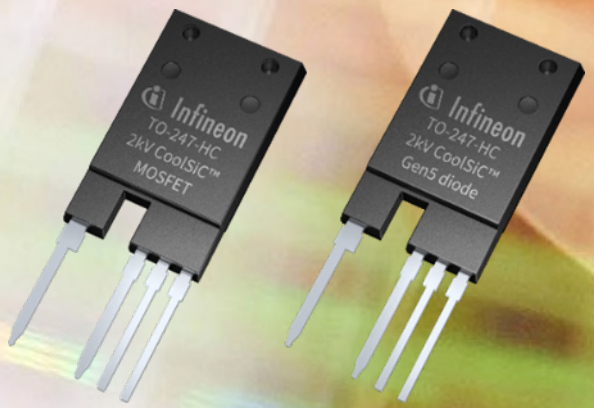


No viable Si solution, even 1.2 kV SiC gets complicated...

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

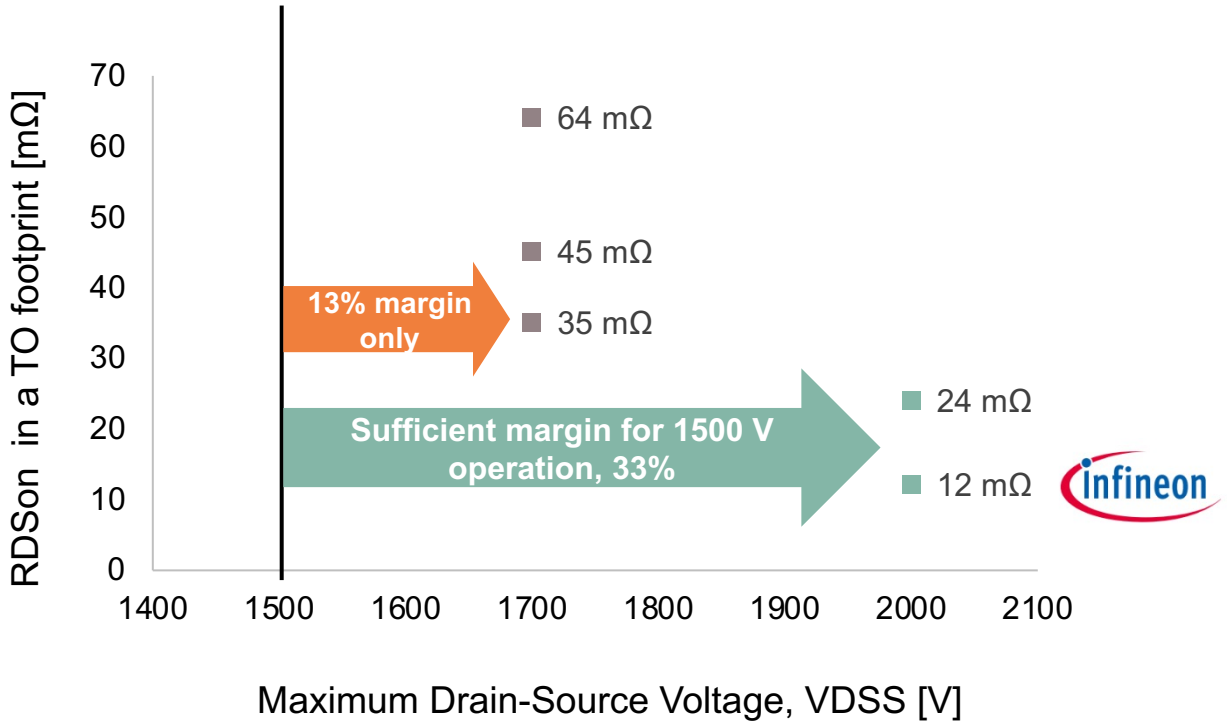
- Technology designed to have both low $R_{DS(on)}$*A and low FiT rate at 1500 V DC
- Base technology has passed all relevant qualification tests
- The latest CoolSiC™ technology gives full freedom in choosing the gate voltage during turn-off
- New package with higher creepage and clearance distance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



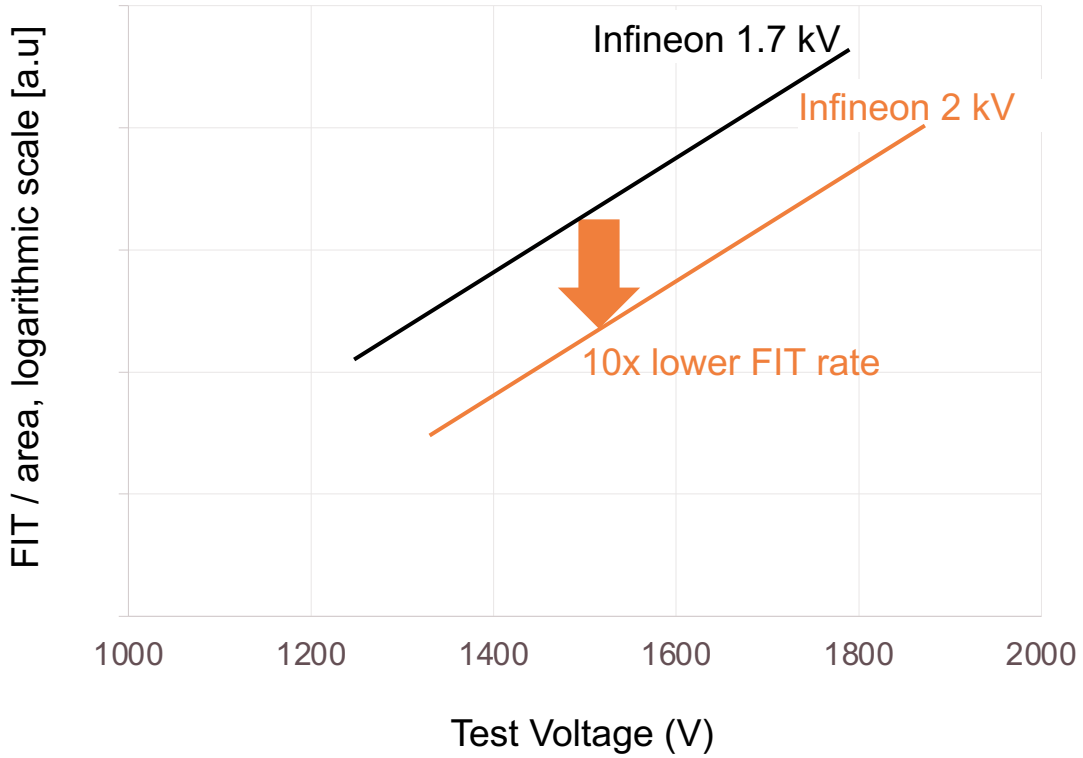


No more pain with powering systems from 1500 V DC: 2 kV CoolSiC™ creates a new benchmark in power density

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

Base technology has passed all relevant qualification test, especially these extended 2 kV relevant tests

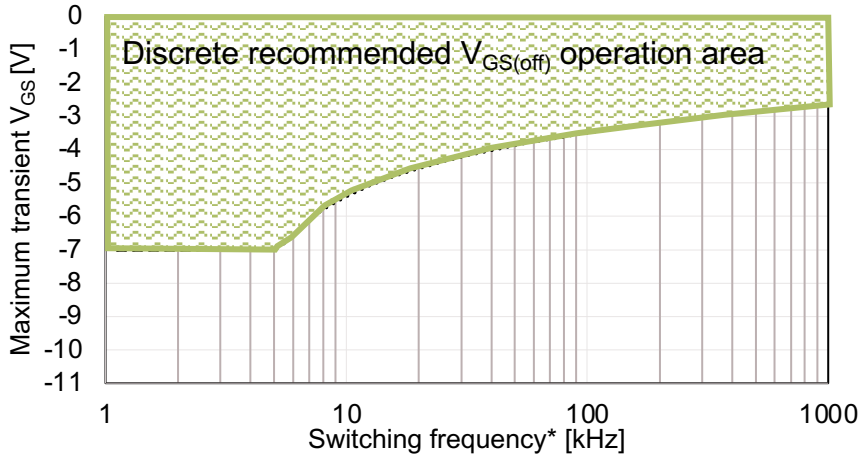
Test	Test conditions	Serial release: stress time
HTRB	V_{DS} = **1800 V** T = Tvjop_max	1000 h
HTGS	V_{DS} = 0 V V_{GS} = +23 V/-20 V T = Tvjop_max	1000 h
HV-H3TRB	V_{DS} = **1600 V** T = **85°C** Relative humidity = **85%**	1000 h
Dynamic H3TRB	V_{DS} = pulsed voltage T = 85°C Relative humidity = 85%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

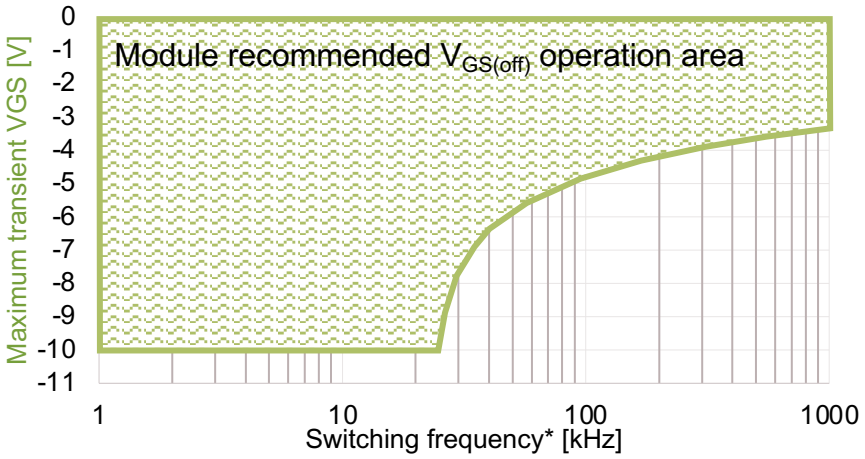
Long-term stability test at voltage level associated to 2 kV

Full humidity robustness according to harsh environment condition

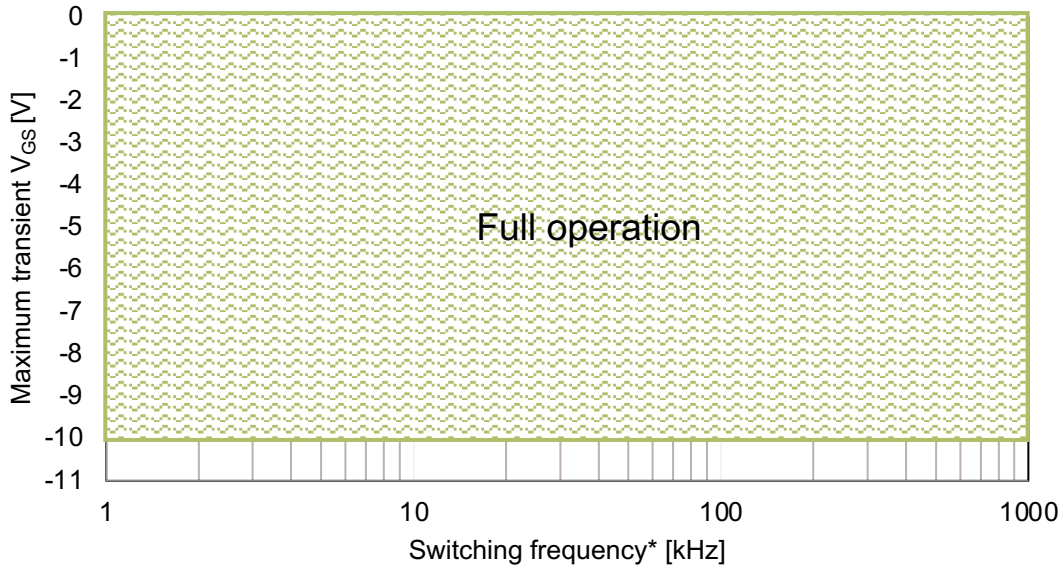
In addition to 2 kV voltage, the latest CoolSiC™ base technology advancements gives full freedom in choosing the gate voltage

Previous gate voltage recommendation area





New gate voltage recommendation area



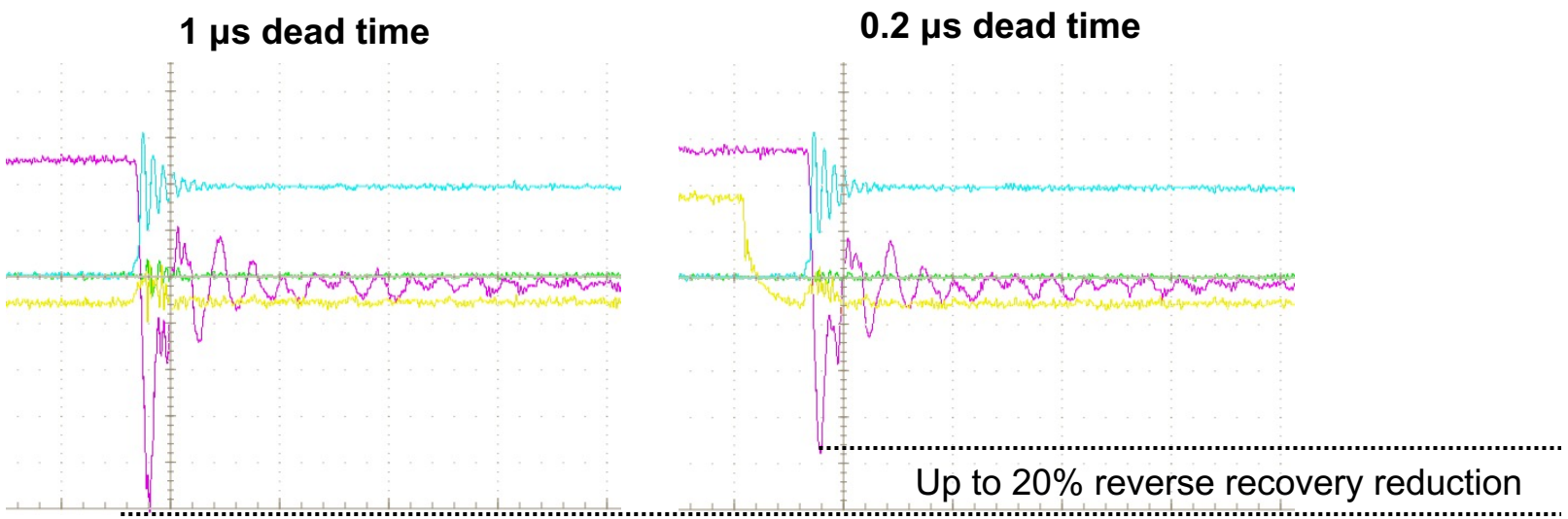
Ease of use with maximum negative gate-source voltage down to -10 V

*Assuming 10 years of continuous operation. For more details see Application Note AN2018-09

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

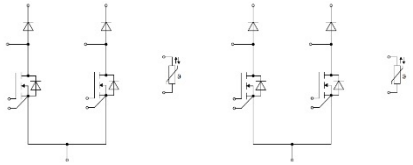


Reducing dead time in hard switching condition will

→ **Reduce E_{on} loss**

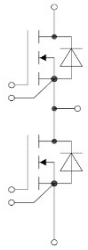
→ **Reduce EMI**

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

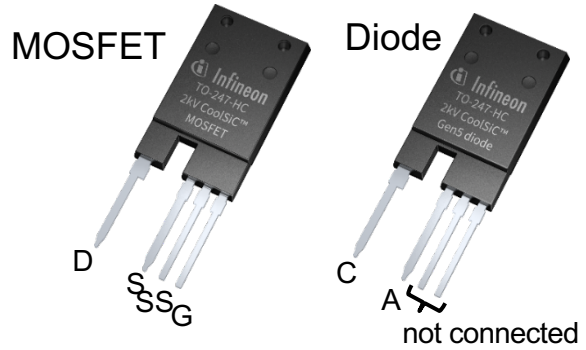
R_{DSon} [mOhm]	Product
19	DF4-19MR20W3M1HF_B11



- 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*

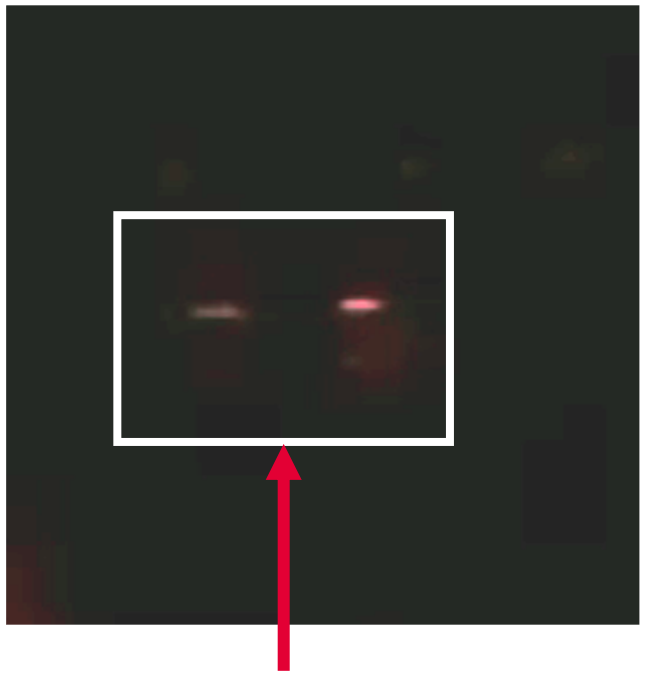
- Will be available with TIM, indicated by P at the end
- Will be available as common source configuraiton, indicated by _S at the end



- 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

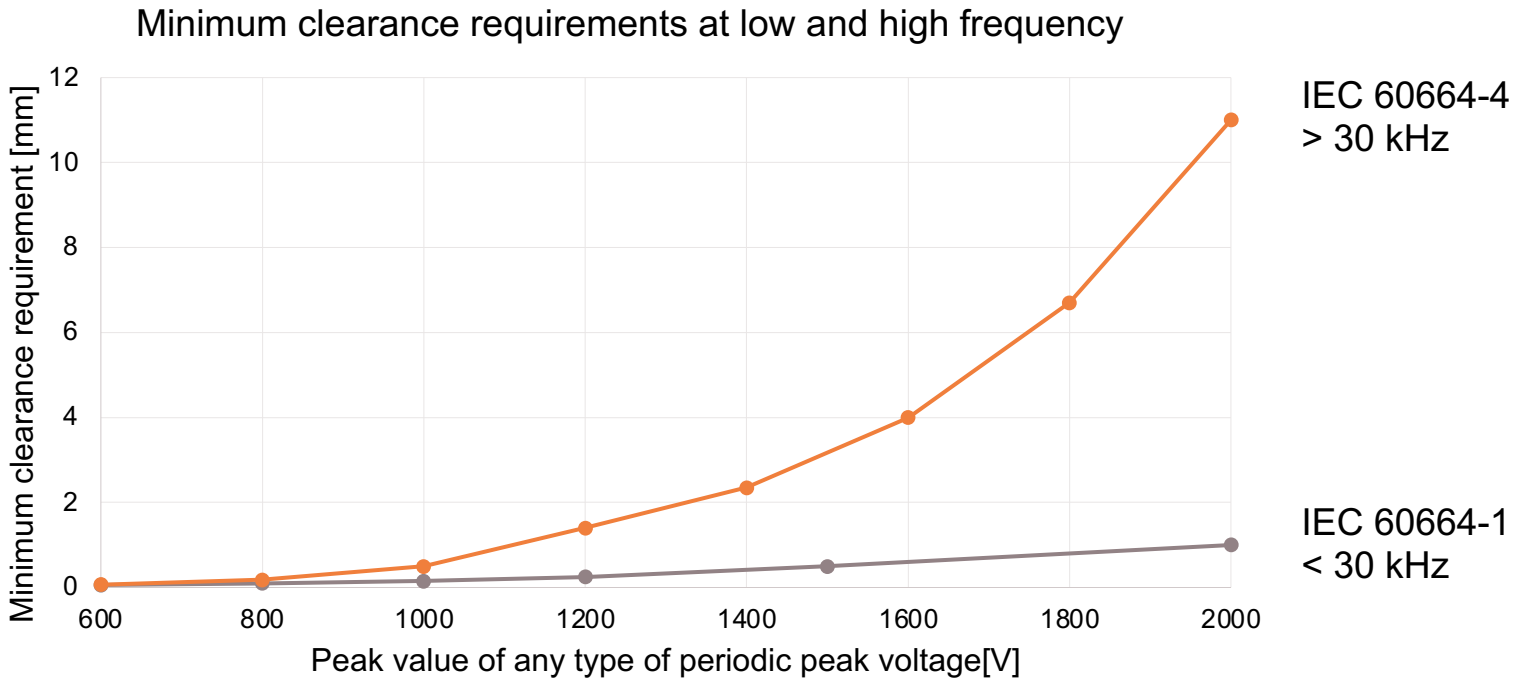
*https://www.der-deutsche-innovationspreis.de/

Higher voltage in combination with higher frequency requires much higher clearance



Corona high frequency discharge

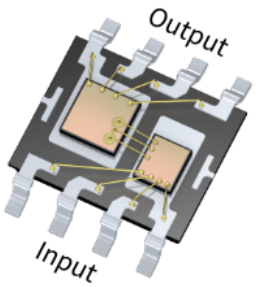
Test conditions:	TO247 3 pin
Clearance distance:	~ 2,6 mm
Continuous turn off voltage spike:	~ 1,6 kV
Switching freq.:	~ 80 kHz



- Clearance distance requirement is much higher with higher switching frequency
- Extra care needs to be considered in system design

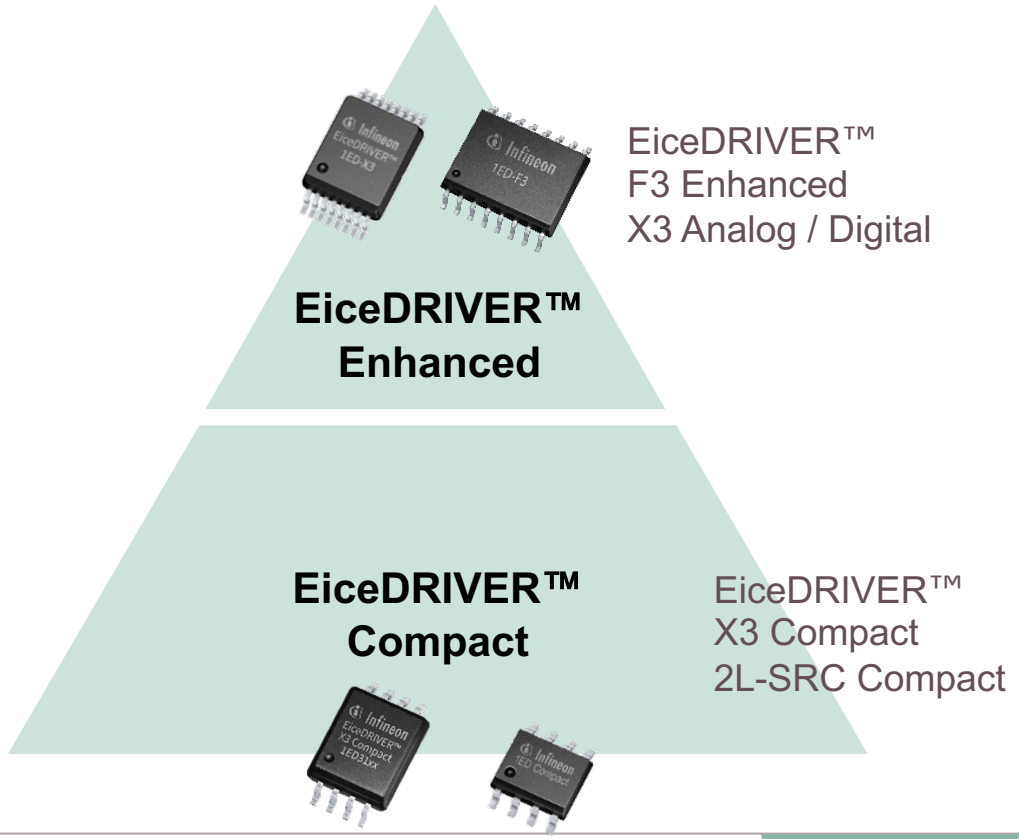
EiceDRIVER™ isolated gate driver portfolio – The perfect match to support 2 kV CoolSiC™ MOSFET discrete and module

- 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**

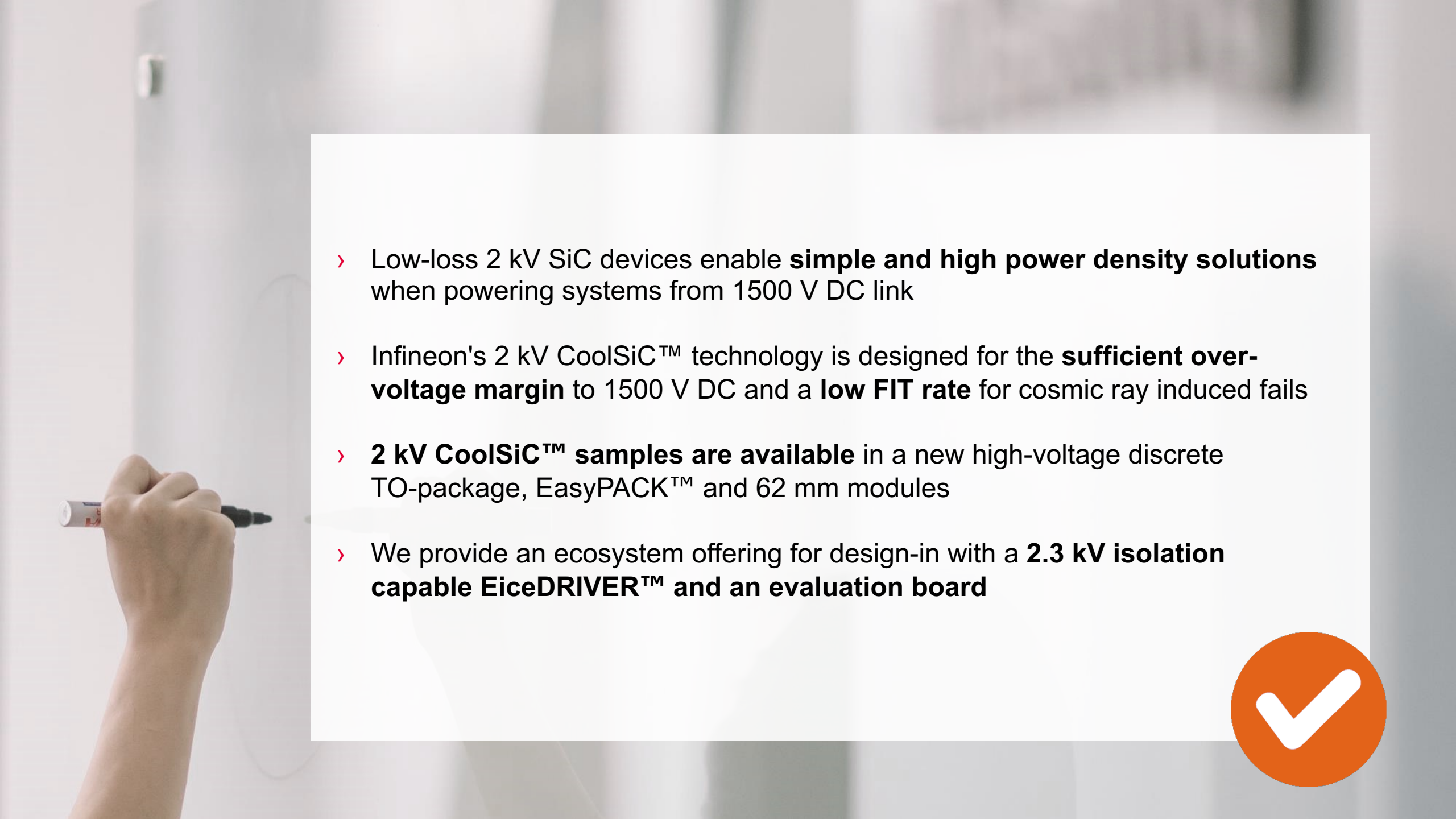


Coreless Transformer technology

Source: Infineon US



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



- 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™ and an evaluation board**

Part of your life. Part of tomorrow.