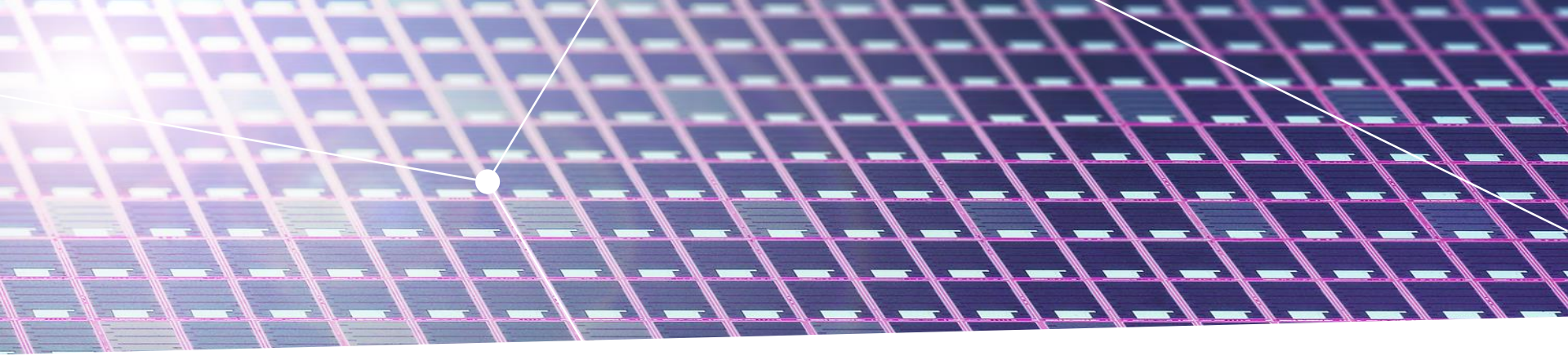

CoolSiC™ MOSFET
Frequently Asked Questions

June, 2020

Why should I use CoolSiC™ MOSFET devices?

- Infineon's SiC MOSFET devices are called CoolSiC™ MOSFET.
- CoolSiC™ MOSFET devices can reduce switching losses by about 80% and conduction losses by up to 50% compared to Si based IGBTs, depending on the load conditions.
- This leads to a significant reduction in operational costs, since inverter efficiency levels exceeding 99% can be achieved.
- Because of the specific SiC properties, the same or even higher switching-frequency operations can be implemented.
- This is particularly attractive for topologies operating under high switching frequencies, typically found in photovoltaic inverters, UPS, DC EV chargers and battery chargers used for energy storage.
- In addition to this, the CoolSiC™ MOSFET devices enable engineers to reduce system costs by increasing power density.

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Which nomenclature does Infineon use for CoolSiC™ MOSFET devices?

For CoolSiC™ MOSFET Infineon uses a similar nomenclature as for IGBT modules. The main difference is that the R_{DSon} is used instead of the nominal current in the device name following the initial letter combination indicating the module configuration or package type (discrete devices).

- **Example: FF6MR12W2M1**
  - FF: Half-bridge
  - 6MR: 6 mOhm
  - 12: rated maximum blocking voltage divided by 100
  - W2: Easy2B
  - M1: CoolSiC™ MOSFET 1st Generation

- **Example: IMW120R045M1**
  - I: Infineon
  - M: CoolSiC™ MOSFET
  - W: TO247 3pin package
  - 120: rated maximum blocking voltage divided by 10
  - R045: 45 mOhm
  - M1: CoolSiC™ MOSFET 1st Generation

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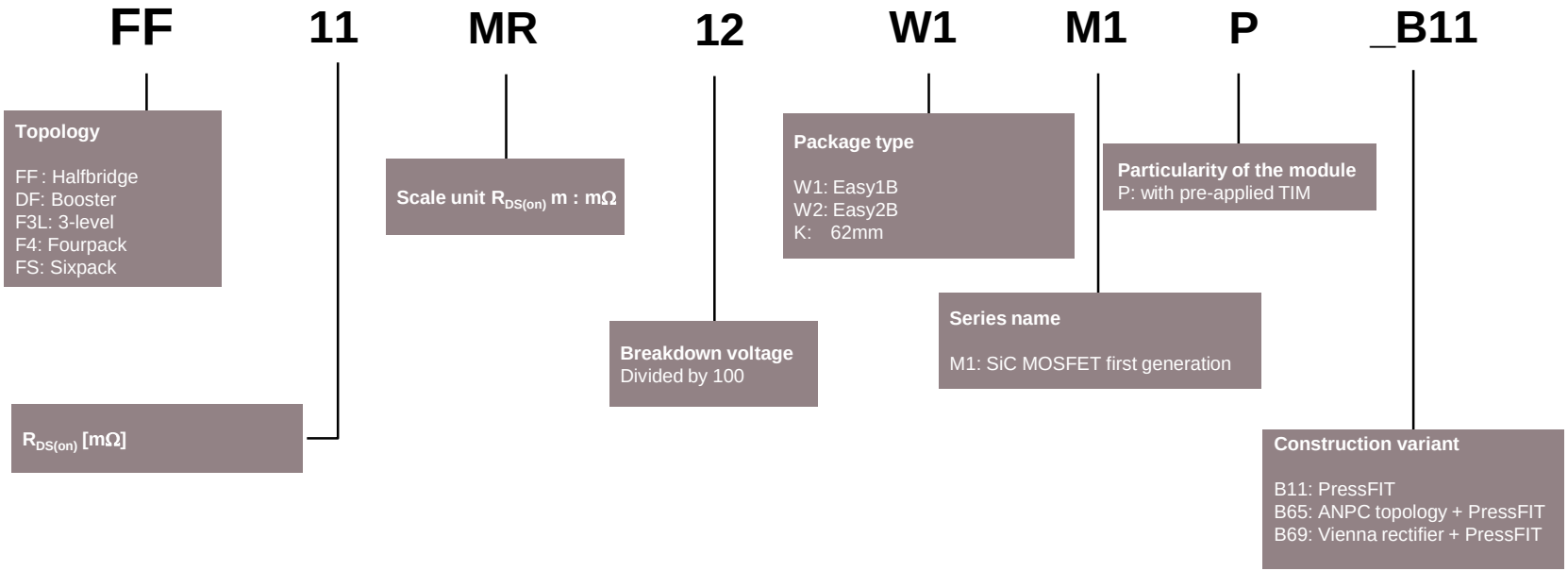
CoolSiC™ MOSFET modules



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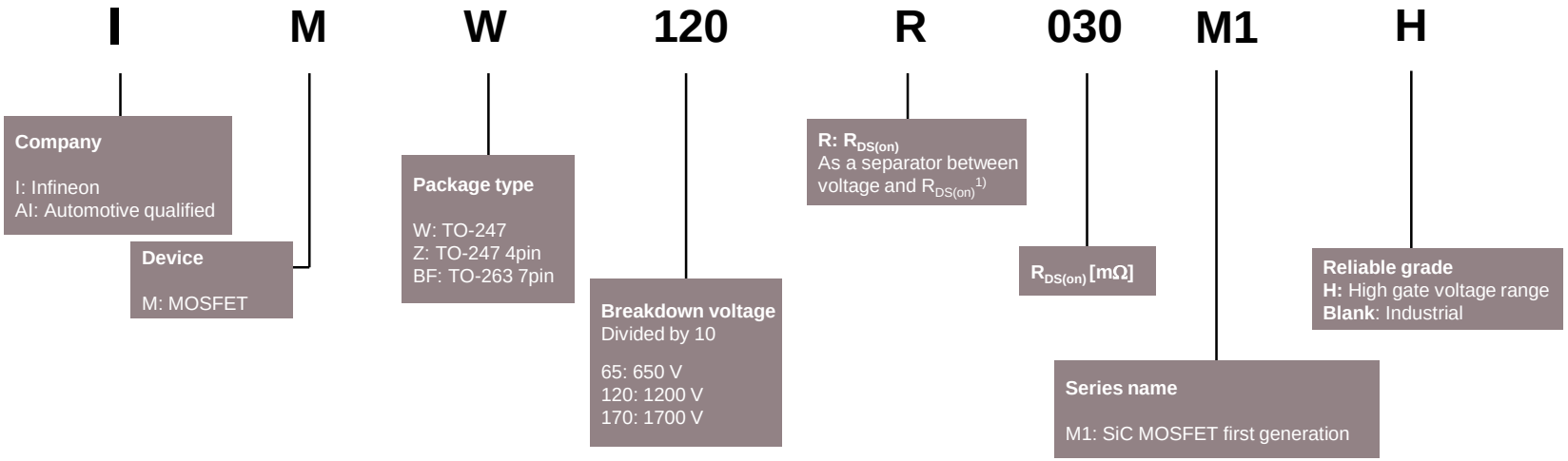
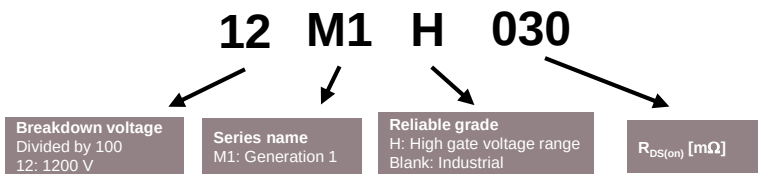
CoolSiC™ MOSFET discretes



Marking pattern
(see technical data sheet)



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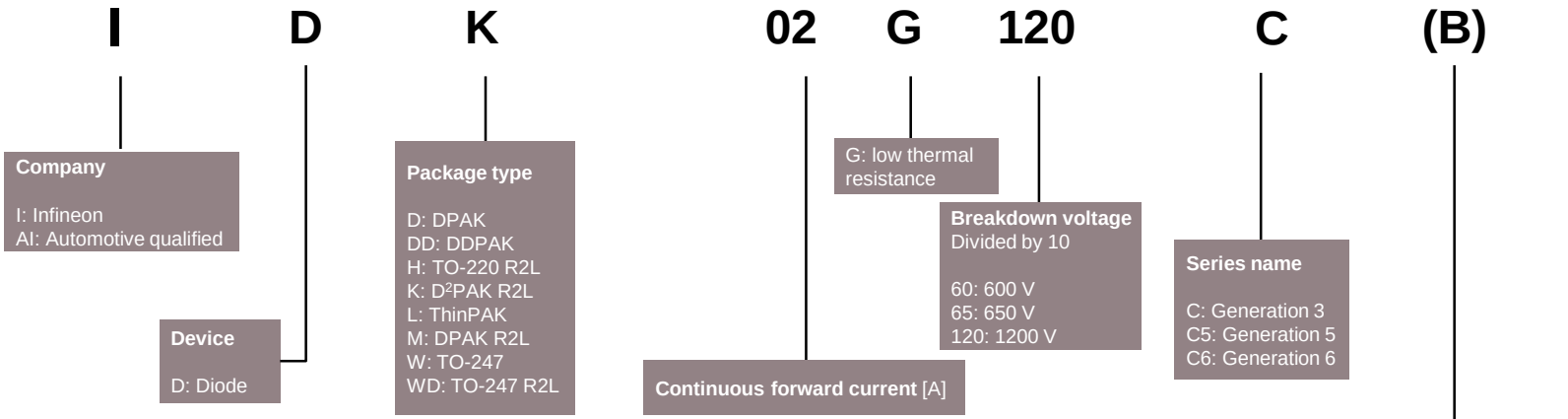
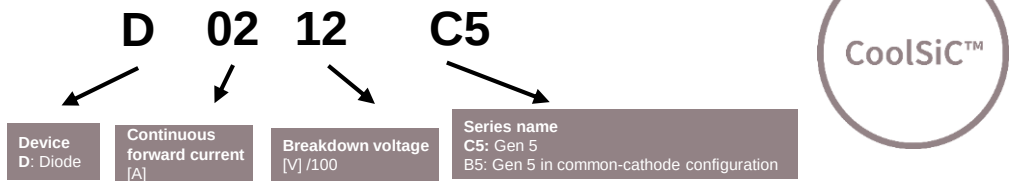
CoolSiC™ Schottky diode



Marking pattern
(see technical data sheet)



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What gate drivers can be used for CoolSiC™ MOSFET devices?

- CoolSiC™ MOSFETs are fast-switching AND high-voltage devices, whose common mode transients (CMT) can reach and exceed 50 V/ns. Higher switching speed requires higher gate drive current as well as well-matched delays and accurate timing.
- CoolSiC™ MOSFETs may need a negative gate voltage or a Miller clamp. In addition, CoolSiC™ MOSFETs may need faster short-circuit protection as their short-circuit withstand time is smaller than with traditional IGBTs.
- In case short-circuit capability is not required, higher gate voltage may be utilized to reduce R_{DSon}.

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EiceDRIVER™ ICs are a perfect fit to CoolSiC™ MOSFET

Features:

- Three families to perfectly match design requirements:
  - 4 single-channel high-side compact gate drivers
  - 2 single- and dual output enhanced drives with short-circuit protection
  - 1 slew-rate control high-side driver for toughest requirements
- Available in wide body package with 7.6 mm creepage distance
- Suitable for operation at high ambient temperature
- Active Miller clamp
- Short-circuit clamping and active shutdown
- ≥ 100 kV/µs CMTI (1EDU20I12SV: ≥ 50 kV/µs CMTI)
- Precision short-circuit protection (via DESAT)
- 12 V/ 11 V typical UVLO thresholds

Part Number	Typical Peak Drive Current	VCC2-VEE2	Typical Propagation Delay	Active Miller Clamp	Other Key Features
1EDI20I12MF DSO-8 150mil	3.5 A	20 V	≤ 300 ns	Yes	Functional Isolation
1EDC20H12AH DSO-8 300mil	3.5 A	40 V	≤ 125 ns	No	7.6 mm Creepage Clearance; UL 1577 certified with V_{ISO} = 2.5 kV(rms) for 1 min
1EDC60H12AH DSO-8 300mil	9.4 A	40 V	≤ 125 ns	No	
1EDC20I12MH DSO-8 300mil	3.5 A	20 V	≤ 300 ns	Yes	
1ED020I12-F2 DSO-16 300mil	2.0 A	28 V	≤ 170 ns	Yes	Short circuit clamping; DESAT protection; Active shutdown
2ED020I12-F2 DSO-36	2.0 A	28 V	≤ 170 ns	Yes	
1EDU20I12SV DSO-36	2.0 A	28 V	≤ 485 ns	Yes	Real-time adjustable gate current control; Over-current protection; Soft turn-off shut down; Two-level turn-off; UL 1577 certified with V_{ISO} = 5 kV(rms) for 1 min

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Are there specific design recommendations for optimizing the layout?

- The interconnection between gate driver and the CoolSiC™ MOSFET device should have a minimum inductance, and mutual inductance with the load circuit. This means the driver should be located as close as possible to the device.
- Capacitive coupling from the drain to the driver and to other parts of the circuit has to be minimized. Overlapping of this potential with other signals has to be avoided wherever possible.
- The switching behavior of Infineon's CoolSiC™ MOSFET is highly controllable via the gate resistor. Therefore, the gate resistor should be selected for an optimum trade-off between minimizing switching loss vs. overshoots and oscillations.

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Do CoolSiC™ MOSFETs have a body diode?

- Yes, all CoolSiC™ MOSFET devices packaged in Infineon modules or Infineon's discrete portfolio have a body diode integrated, which is released for operation.
- An additional Schottky diode is not required.

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Does your body diode drift? Can the CoolSiC™ MOSFET be used without external Schottky Barrier Diode (SBD)?

- The diode is drift free. It can be used without an SBD.
- It is recommended to use synchronous rectification (turn on the channel in diode mode after a short dead time) to benefit from low conduction losses.

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How can you make sure that your diode does not drift while parts from other vendors show drift?

- We have implemented measures in processing and testing to make sure that no defective parts which could lead to measurable drift are shipped to the customer.

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How to deal with EMI topics?

- A substantial source of EMI in silicon-based systems (shape of the silicon pn junction-based freewheeling diode's I_{rr} curve) is eliminated by using CoolSiC™ MOSFETs.

- Further EMI issues, arising from the fast switching behaviour, can have various sources, e.g. board design, parasitics etc. The chip itself creates additional EMI challenges due to fast switching. Possible countermeasures include:

  - Improvement of the overall design, mainly symmetry is highly important
  - Use of slew rate control at the gate drive to adjust the dv/dt during certain moments of the switching process
  - Slowing down the chip via R_G to the desired dv/dt

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What are the differences compared to an IGBT?

- IGBTs and MOSFETs have only partial similarities, mainly in the control via a bias at the gate (charge-controlled device). The CoolSiC™ MOSFET as a unipolar device is generally thermally limited within its SOA (Safe Operating Area), thus, the Z_{TH} curve can be used to estimate limits.
  - Limits arising from minority carrier dynamics as known from the IGBT, e.g. a limited current handling capability (at turn-off) at high V_{DS}, does not apply.
  - Latch-up effects (turn-on of a bipolar pnp transistor) are suppressed by the high V_{BE} (due to V_{bi} of SiC pn junctions) required to activate a parasitic bipolar transistor, and by the low current gain of the SiC npn transistor
  - FBSOA of a CoolSiC™ MOSFET is usually rectangular (pulsed operation, for V_{GS}>12V)
  - RBSOA: turn-off with presence of many holes in the active areas of IGBT's is not present in CoolSiC™ MOSFETs
- Application notes dealing with IGBT properties can only be partially transferred to CoolSiC™ MOSFETs.

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How similar is the CoolMOS™ MOSFET to the CoolSiC™ MOSFET?

- Fast-switching devices like Si super-junction MOSFETs and CoolSiC™ MOSFET have many similar properties, e.g. temperature-independent switching losses, increase of R_{on} with temperature, etc.
- Unlike the CoolMOS™ device, the CoolSiC™ MOSFET benefits from negligible Q_{rr} and the very small Q_{oss}
- Application notes describing design measures to manage high switching speeds can also be used for CoolSiC™ MOSFETs.

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What is the recommended gate voltage scheme?

- **Turn-on state:**
  - $V_{gs,on}$= 15 V is recommended if short-circuit capability is needed in the application (e.g. motor drives or inverters for automotive application)
  - $V_{gs,on}$= 18 V is recommended for highest power handling capability (lowest R_{DSon}) when no short-circuit capability is needed
  - It is important to note that any gate voltage over-shoot is not exceeding the maximum specified V_{GSS} in the datasheet

- **Turn-off state:**
  - 0 V turn-off can usually be applied as CoolSiC™ MOSFET technology has a high robustness against parasitic turn-on (0 V gate drive scheme especially valid for discrete products like TO247 and D^2PAK-7L)
  - For both discrete and module CoolSiC™ MOSFET products a lower turn-off voltage, e.g. -5 V for automotive applications, can be implemented according to AN-2018-09.

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Is Infineon’s CoolSiC™ MOSFET avalanche-capable ?

- The CoolSiC™ MOSFET does offer a certain avalanche capability.
- The basic behavior is similar to the one known from silicon MOSFETs.

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Can the CoolSiC™ MOSFET be paralleled? What about dynamic imbalances?

› Due to the positive temperature coefficient for the relevant parameters (like R_{DSon}, E_{tot}) the static current sharing of paralleled CoolSiC™ MOSFETs is easy to maintain.

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