

## MOSFET

### 650 V CoolSiC™ M1 SiC Trench Power Device

The 650 V CoolSiC™ is built over the solid silicon carbide technology developed in Infineon in more than 20 years. Leveraging the wide bandgap SiC material characteristics, the 650V CoolSiC™ MOSFET offers a unique combination of performance, reliability and ease of use. Suitable for high temperature and harsh operations, it enables the simplified and cost effective deployment of the highest system efficiency.

#### Features

- Optimized switching behavior at higher currents
- Commutation robust fast body diode with low  $Q_f$
- Superior gate oxide reliability
- $T_{j,max}=175^{\circ}\text{C}$  and excellent thermal behavior
- Lower  $R_{DS(on)}$  and pulse current dependency on temperature
- Increased avalanche capability
- Compatible with standard drivers (recommended driving voltage: 0V-18V)
- Kelvin source provides up to 4 times lower switching losses

#### Benefits

- Unique combination of high performance, high reliability and ease of use
- Ease of use and integration
- Suitable for topologies with continuous hard commutation
- Higher robustness and system reliability
- Efficiency improvement
- Reduced system size leading to higher power density

#### Potential applications

- Telecom and Server SMPS
- UPS (uninterruptable power supplies)
- Solar PV inverters
- EV charging infrastructure
- Energy storage and battery formation
- Class D amplifiers

#### Product validation

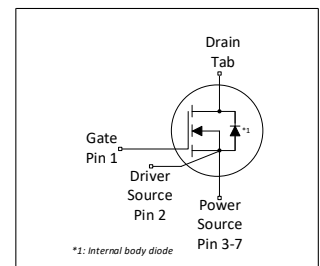
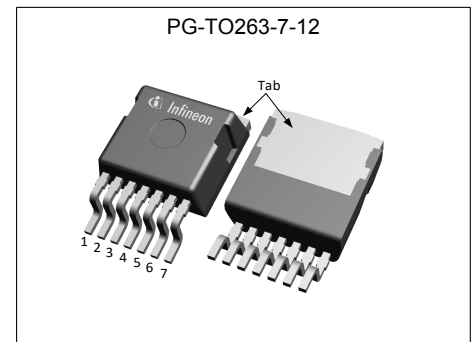
Fully qualified according to JEDEC for Industrial Applications

*Please note: The source and sense source pins are not exchangeable. Their exchange might lead to malfunction.*

**Table 1 Key Performance Parameters**

| Parameter                           | Value | Unit          |
|-------------------------------------|-------|---------------|
| $V_{DS} @ T_J = 25^{\circ}\text{C}$ | 650   | V             |
| $R_{DS(on),typ}$                    | 72    | m $\Omega$    |
| $R_{DS(on),max}$                    | 94    | m $\Omega$    |
| $Q_{G,typ}$                         | 22    | nC            |
| $I_{DM}$                            | 69    | A             |
| $Q_{oss} @ 400\text{ V}$            | 52    | nC            |
| $E_{oss} @ 400\text{ V}$            | 7.8   | $\mu\text{J}$ |

| Type / Ordering Code | Package       | Marking  | Related Links  |
|----------------------|---------------|----------|----------------|
| IMBG65R072M1H        | PG-TO263-7-12 | 65R072M1 | see Appendix A |



RoHS

## Table of Contents

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## 1 Maximum ratings

at  $T_J = 25\text{ °C}$ , unless otherwise specified

**Table 2 Maximum ratings**

| Parameter   | Symbol    | Values |      |          | Unit | Note / Test Condition   |
|---|-----------|--------|------|----------|------|---|
|   |           | Min.   | Typ. | Max.     |      |   |
| Continuous DC drain current <sup>1)</sup>           | $I_D$     | -      | -    | 33<br>23 | A    | $T_C = 25\text{ °C}$<br>$T_C = 100\text{ °C}$   |
| Peak drain current <sup>2)</sup>                    | $I_{DM}$  | -      | -    | 69       | A    | $T_C = 25\text{ °C}$  |
| Avalanche energy, single pulse                      | $E_{AS}$  | -      | -    | 114      | mJ   | $I_D = 4.3\text{ A}$ , $V_{DD} = 50\text{ V}$ ; see table 11                              |
| Avalanche energy, repetitive                        | $E_{AR}$  | -      | -    | 0.57     | mJ   | $I_D = 4.3\text{ A}$ , $V_{DD} = 50\text{ V}$ ; see table 11                              |
| Avalanche current, single pulse                     | $I_{AS}$  | -      | -    | 4.3      | A    | -   |
| MOSFET $dv/dt$ ruggedness                           | $dv/dt$   | -      | -    | 200      | V/ns | $V_{DS} = 0\text{...}400\text{ V}$  |
| Gate source voltage (static) <sup>3)</sup>          | $V_{GS}$  | -5     | -    | 23       | V    | static  |
| Gate source voltage (transient)                     | $V_{GS}$  | -7     | -    | 25       | V    | $t_{pulse, positive} \leq 1\%$ duty cycle/ $f_{sw}$                                       |
| Power dissipation                                   | $P_{tot}$ | -      | -    | 140      | W    | $T_C = 25\text{ °C}$  |
| Storage temperature                                 | $T_{stg}$ | -55    | -    | 150      | °C   | -   |
| Operating junction temperature                      | $T_J$     | -55    | -    | 175      | °C   | -   |
| Mounting torque                                     | -         | -      | -    | n.a.     | Ncm  | -   |
| Continuous reverse drain current <sup>1)</sup>      | $I_{SDC}$ | -      | -    | 33<br>22 | A    | $V_{GS}=18\text{ V}$ , $T_C = 25\text{ °C}$<br>$V_{GS}=0\text{ V}$ , $T_C = 25\text{ °C}$ |
| Repetitive peak reverse drain current <sup>1)</sup> | $I_{SRM}$ | -      | -    | 69       | A    | $T_C = 25\text{ °C}$ , pulse width $t_p \leq 250\text{ ns}$                               |
| Insulation withstand voltage                        | $V_{ISO}$ | -      | -    | n.a.     | V    | $V_{rms}$ , $T_C = 25\text{ °C}$ , $t = 1\text{ min}$                                     |

<sup>1)</sup> Limited by  $T_{J,max}$

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{J,max}$

<sup>3)</sup> The maximum gate-source voltage in the application design should be in accordance to IPC-9592B

## 2 Thermal characteristics

**Table 3 Thermal characteristics**

| Parameter   | Symbol     | Values |      |      | Unit | Note / Test Condition   |
|---|------------|--------|------|------|------|---|
|   |            | Min.   | Typ. | Max. |      |   |
| Thermal resistance, junction - case                     | $R_{thJC}$ | -      | -    | 1.07 | °C/W | -   |
| Thermal resistance, junction - ambient                  | $R_{thJA}$ | -      | -    | 62   | °C/W | device on PCB, minimal footprint  |
| Thermal resistance, junction - ambient for SMD version  | $R_{thJA}$ | -      | 35   | 45   | °C/W | Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm <sup>2</sup> (one layer, 70µm thickness) copper area for drain connection and cooling. PCB is vertical without air stream cooling. |
| Soldering temperature, wave- & reflow soldering allowed | $T_{sold}$ | -      | -    | 260  | °C   | reflow MSL1   |

## 3 Operating range

**Table 4 Operating range**

| Parameter   | Symbol   | Values |      |      | Unit | Note / Test Condition |
|---|----------|--------|------|------|------|-----------------------|
|   |          | Min.   | Typ. | Max. |      |                       |
| Gate-source voltage operating range including undershoots <sup>1)</sup> | $V_{GS}$ | -2     | -    | 20   | V    | -                     |

<sup>1)</sup> **Important note: the selection of positive and negative gate-source voltages impacts the long-term behavior of the device.** The design guidelines described in the CoolSiC™ MOSFET 650 V M1 trench power device application note AN\_1907\_PL52\_1911\_144109 must be considered to ensure sound operation of the device over the planned lifetime.

## 4 Electrical characteristics

at  $T_J = 25\text{ °C}$ , unless otherwise specified

**Table 5 Static characteristics**

| Parameter                            | Symbol        | Values |                |            | Unit          | Note / Test Condition   |
|--------------------------------------|---------------|--------|----------------|------------|---------------|---|
|                                      |               | Min.   | Typ.           | Max.       |               |   |
| Drain-source breakdown voltage       | $V_{(BR)DSS}$ | 650    | -              | -          | V             | $V_{GS} = 0\text{ V}$ , $I_D = 0.4\text{ mA}$   |
| Gate threshold voltage <sup>1)</sup> | $V_{GS(th)}$  | 3.5    | 4.5            | 5.7        | V             | $V_{DS} = V_{GS}$ , $I_D = 4\text{ mA}$   |
| Zero gate voltage drain current      | $I_{DSS}$     | -      | 1<br>3         | 150<br>-   | $\mu\text{A}$ | $V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 25\text{ °C}$<br>$V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 175\text{ °C}$ |
| Gate leakage current                 | $I_{GSS}$     | -      | -              | 100        | nA            | $V_{GS} = 20\text{ V}$ , $V_{DS} = 0\text{ V}$  |
| Drain-source on-state resistance     | $R_{DS(on)}$  | -      | 0.072<br>0.101 | 0.094<br>- | $\Omega$      | $V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ , $T_J = 25\text{ °C}$<br>$V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ , $T_J = 175\text{ °C}$   |
| Internal gate resistance             | $R_G$         | -      | 9.0            | -          | $\Omega$      | $f = 1\text{ MHz}$  |

**Table 6 Dynamic characteristics**

| Parameter  | Symbol       | Values |      |      | Unit | Note / Test Condition  |
|--|--------------|--------|------|------|------|--|
|  |              | Min.   | Typ. | Max. |      |  |
| Input capacitance  | $C_{iss}$    | -      | 744  | -    | pF   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 400\text{ V}$ , $f = 250\text{ kHz}$   |
| Reverse transfer capacitance                               | $C_{riss}$   | -      | 9    | -    | pF   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 400\text{ V}$ , $f = 250\text{ kHz}$   |
| Output capacitance <sup>2)</sup>                           | $C_{oss}$    | -      | 86   | 112  | pF   | $V_{GS} = 0\text{ V}$ , $V_{DS} = 400\text{ V}$ , $f = 250\text{ kHz}$   |
| Output charge <sup>2)</sup>                                | $Q_{oss}$    | -      | 52   | 68   | nC   | calculation based on $C_{oss}$   |
| Effective output capacitance, energy related <sup>3)</sup> | $C_{o(er)}$  | -      | 98   | -    | pF   | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 0\text{...}400\text{ V}$  |
| Effective output capacitance, time related <sup>4)</sup>   | $C_{o(tr)}$  | -      | 129  | -    | pF   | $I_D = \text{constant}$ , $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 0\text{...}400\text{ V}$                                |
| Turn-on delay time   | $t_{d(on)}$  | -      | 6.1  | -    | ns   | $V_{DD} = 400\text{ V}$ , $V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$R_G = 1.8\text{ }\Omega$ ; see table 10 |
| Rise time  | $t_r$        | -      | 7.9  | -    | ns   | $V_{DD} = 400\text{ V}$ , $V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$R_G = 1.8\text{ }\Omega$ ; see table 10 |
| Turn-off delay time  | $t_{d(off)}$ | -      | 12.1 | -    | ns   | $V_{DD} = 400\text{ V}$ , $V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$R_G = 1.8\text{ }\Omega$ ; see table 10 |
| Fall time  | $t_f$        | -      | 7    | -    | ns   | $V_{DD} = 400\text{ V}$ , $V_{GS} = 18\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$R_G = 1.8\text{ }\Omega$ ; see table 10 |

<sup>1)</sup> Tested after 1 ms pulse at  $V_{GS} = +20\text{ V}$

<sup>2)</sup> Maximum specification is defined by calculated six sigma upper confidence bound

<sup>3)</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400 V

<sup>4)</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 400 V

**Table 7 Gate charge characteristics**

| Parameter             | Symbol   | Values |      |      | Unit | Note / Test Condition   |
|-----------------------|----------|--------|------|------|------|---|
|                       |          | Min.   | Typ. | Max. |      |   |
| Gate to source charge | $Q_{gs}$ | -      | 6    | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$V_{GS} = 0\text{ to }18\text{ V}$ |
| Gate to drain charge  | $Q_{gd}$ | -      | 5    | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$V_{GS} = 0\text{ to }18\text{ V}$ |
| Gate charge total     | $Q_g$    | -      | 22   | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_D = 13.3\text{ A}$ ,<br>$V_{GS} = 0\text{ to }18\text{ V}$ |

**Table 8 Body diode characteristics**

| Parameter                            | Symbol    | Values |      |      | Unit | Note / Test Condition   |
|--------------------------------------|-----------|--------|------|------|------|---|
|                                      |           | Min.   | Typ. | Max. |      |   |
| Drain-source reverse voltage         | $V_{SD}$  | -      | 4.0  | -    | V    | $V_{GS} = 0\text{ V}$ , $I_S = 13.3\text{ A}$ , $T_J = 25\text{ °C}$  |
| MOSFET forward recovery time         | $t_{fr}$  | -      | 18.7 | -    | ns   | $V_{DD} = 400\text{ V}$ , $I_{S0} = 13.3\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9 |
| MOSFET forward recovery charge       | $Q_f$     | -      | 60   | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_{S0} = 13.3\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9 |
| MOSFET peak forward recovery current | $I_{frm}$ | -      | 6.1  | -    | A    | $V_{DD} = 400\text{ V}$ , $I_{S0} = 13.3\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9 |

5 Electrical characteristics diagrams

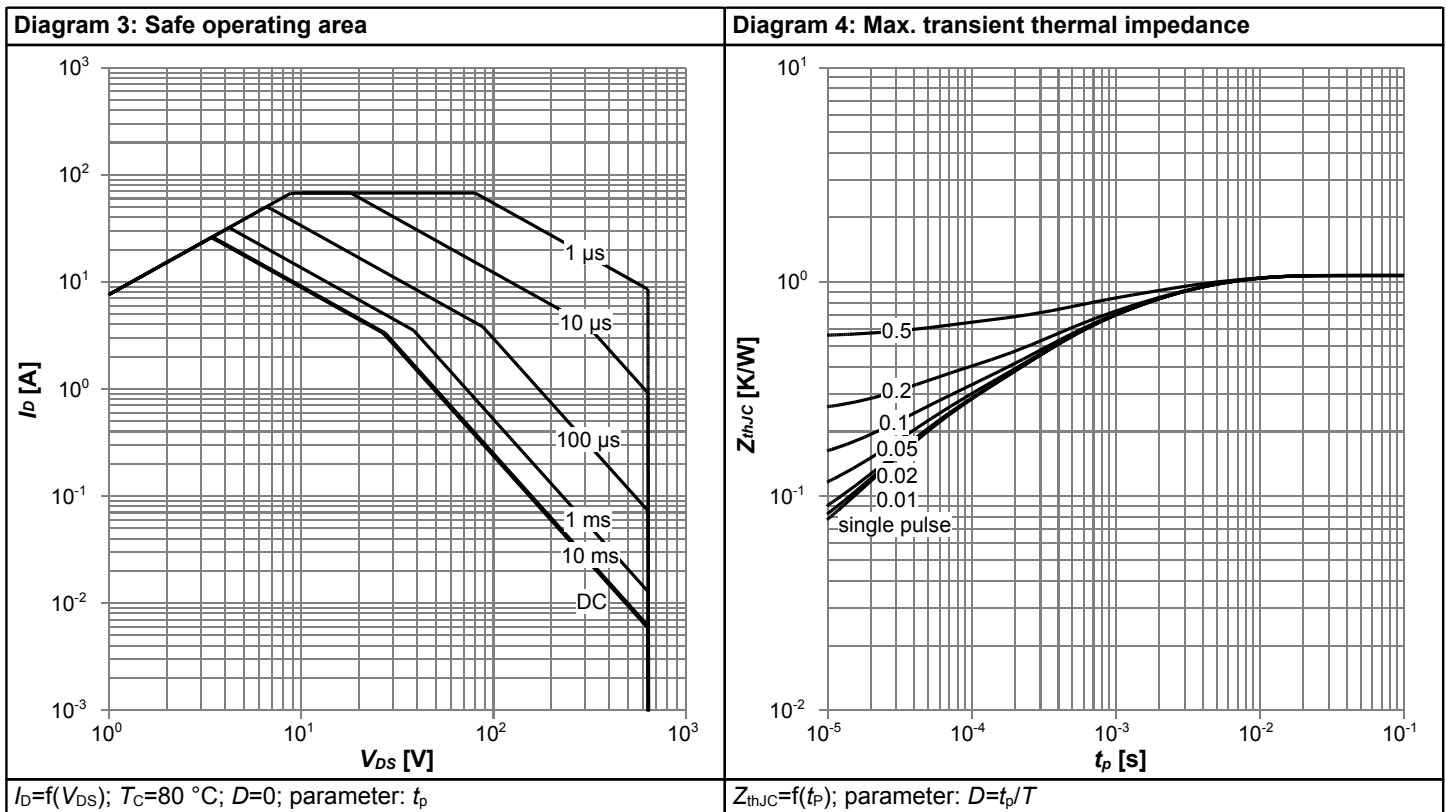
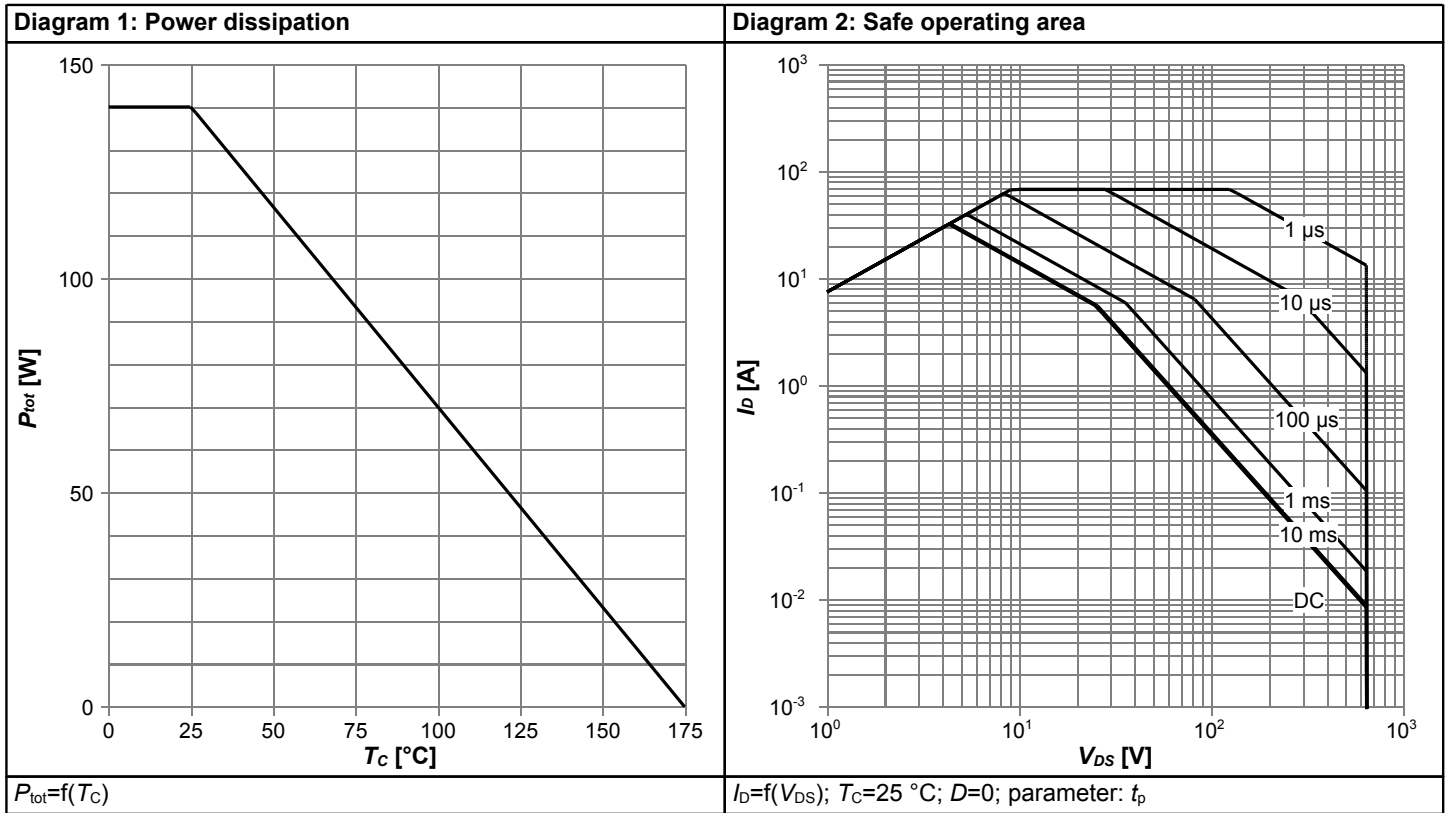
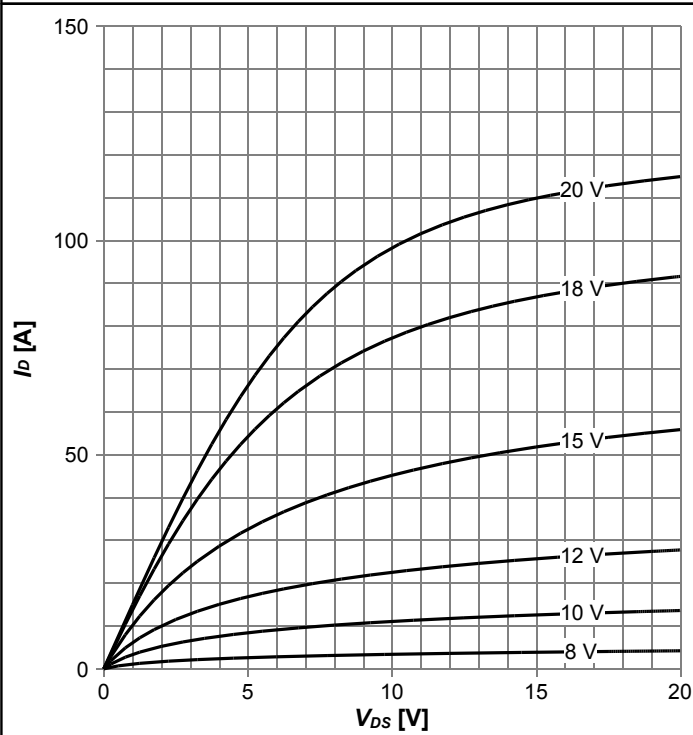
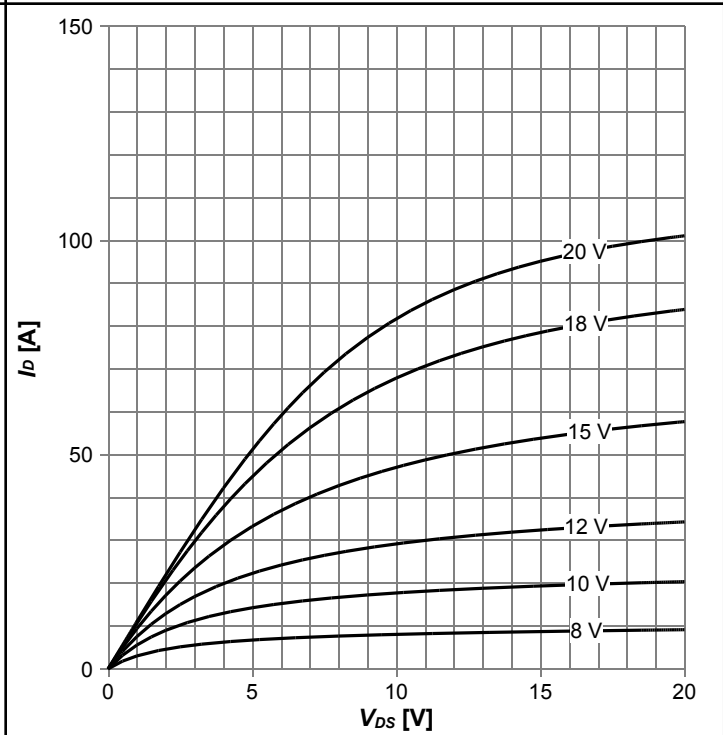


Diagram 5: Typ. output characteristics



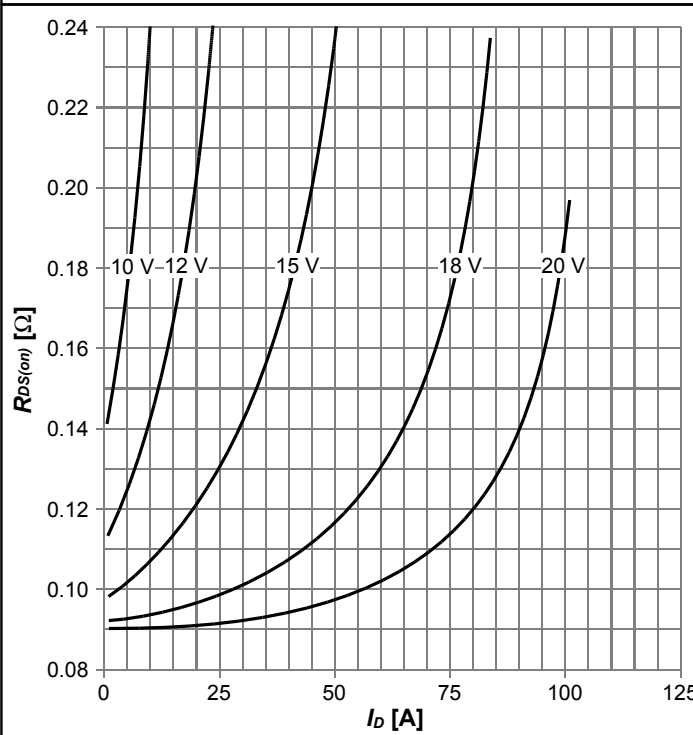
$I_D = f(V_{DS})$ ;  $T_j = 25\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



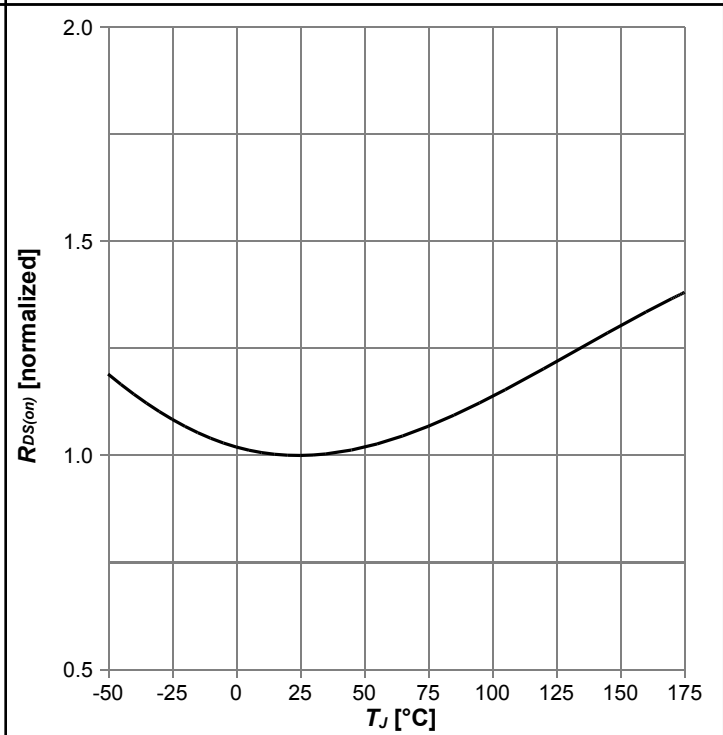
$I_D = f(V_{DS})$ ;  $T_j = 150\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 7: Typ. drain-source on-state resistance



$R_{DS(on)} = f(I_D)$ ;  $T_j = 150\text{ °C}$ ; parameter:  $V_{GS}$

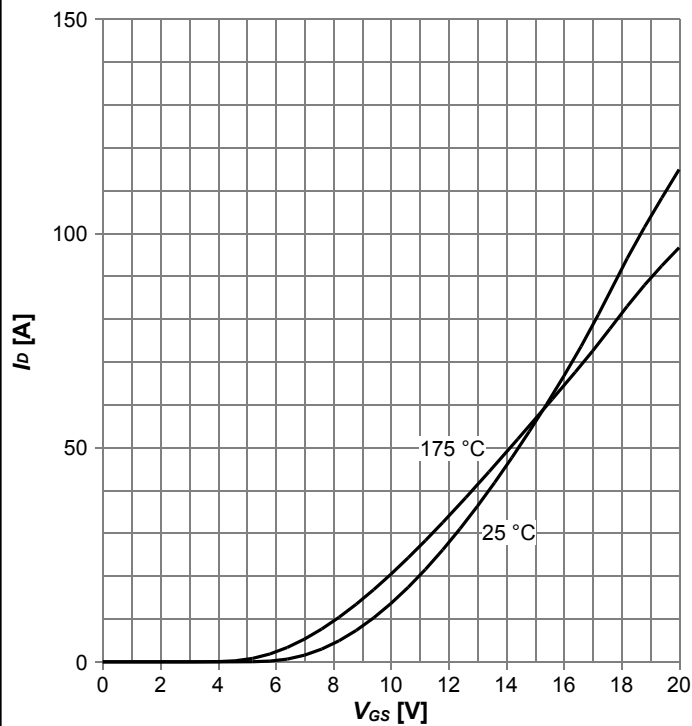
Diagram 8: Drain-source on-state resistance



$R_{DS(on)} = f(T_j)$ ;  $I_D = 13.3\text{ A}$ ;  $V_{GS} = 18\text{ V}$

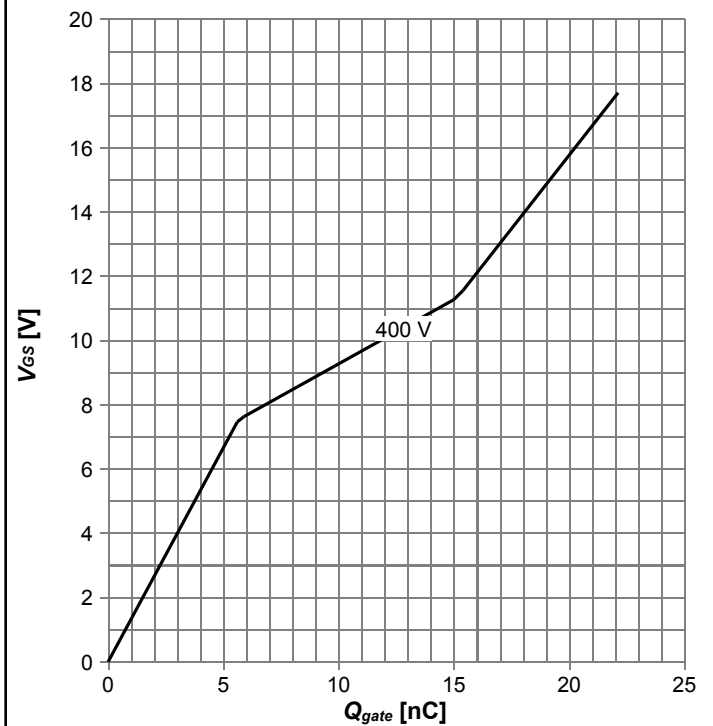


Diagram 9: Typ. transfer characteristics



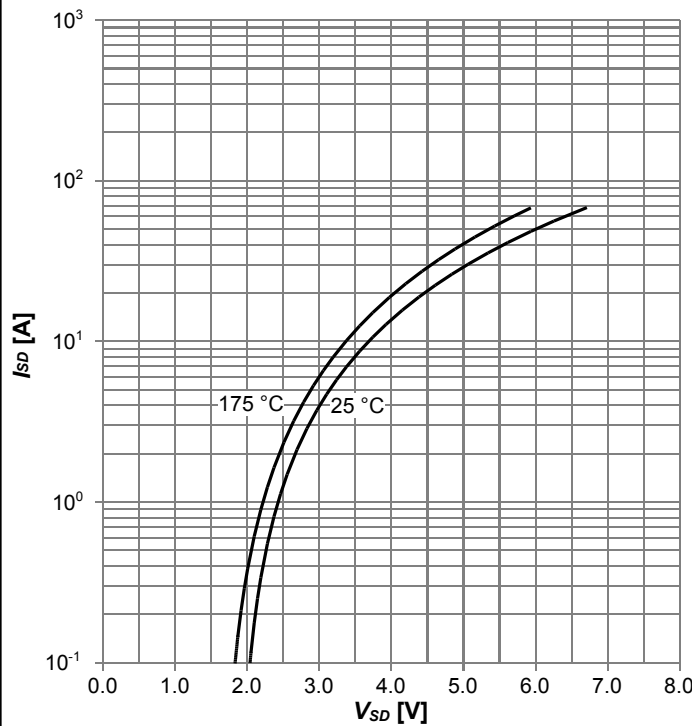
$I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge



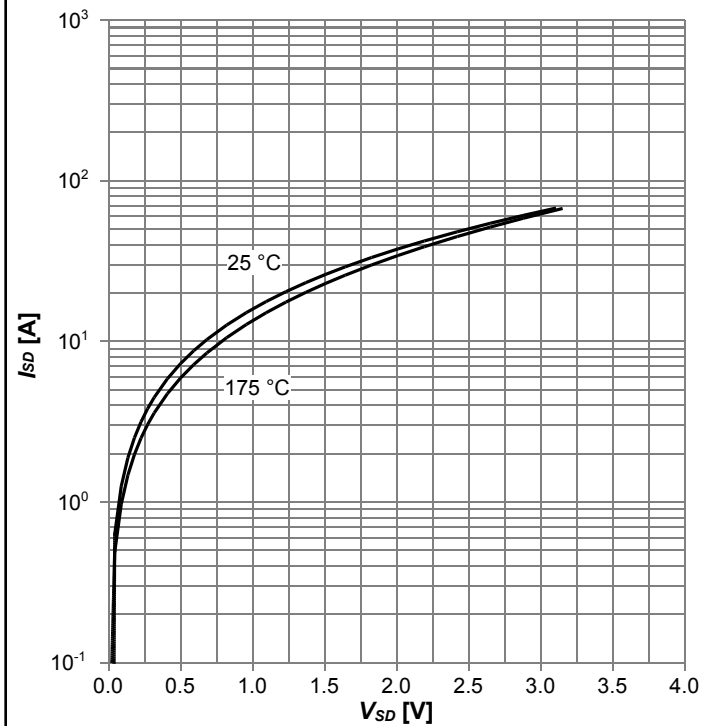
$V_{GS} = f(Q_{gate}); I_D = 13.3 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Typ. reverse characteristics



$I_{SD} = f(V_{SD}); V_{GS} = 0 \text{ V}; \text{parameter: } T_j$

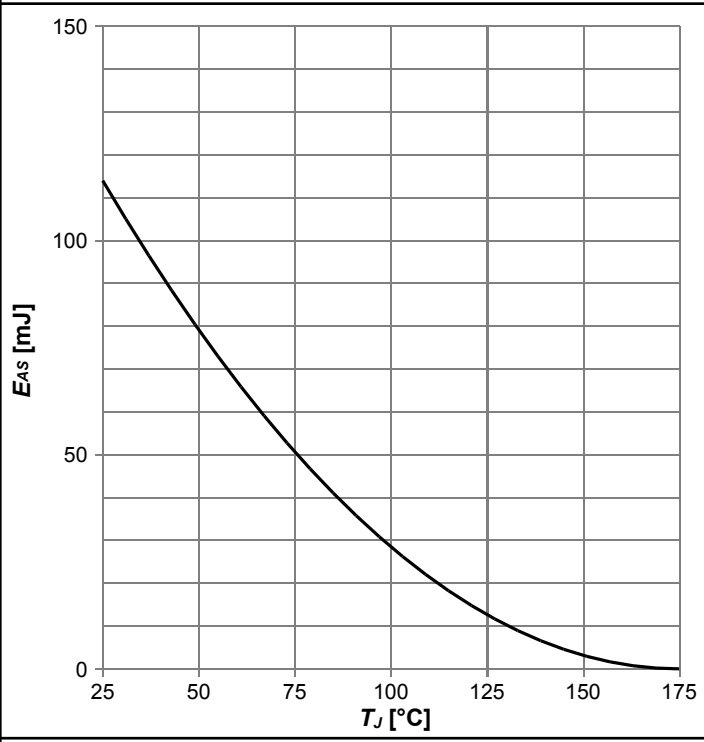
Diagram 12: Typ. reverse characteristics



$I_{SD} = f(V_{SD}); V_{GS} = 18 \text{ V}; \text{parameter: } T_j$

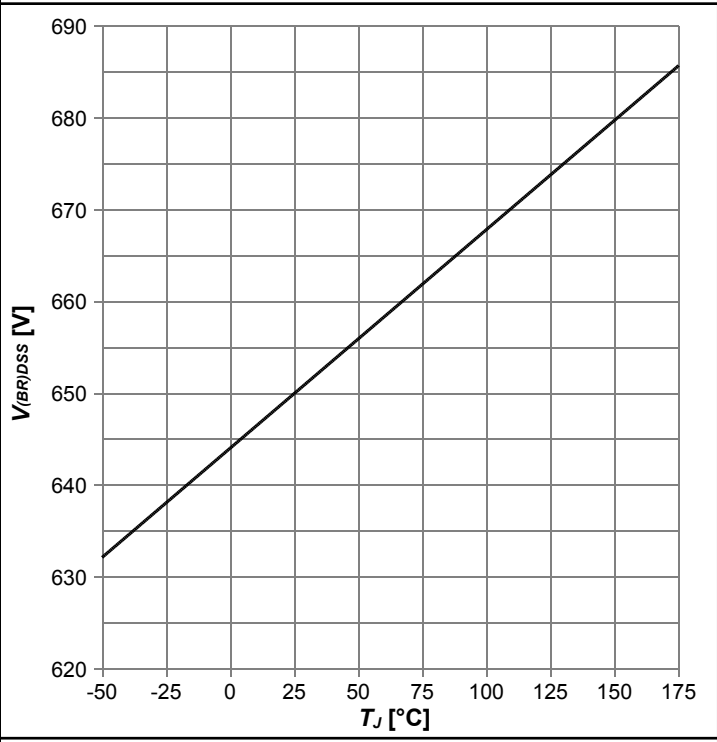


Diagram 13: Avalanche energy



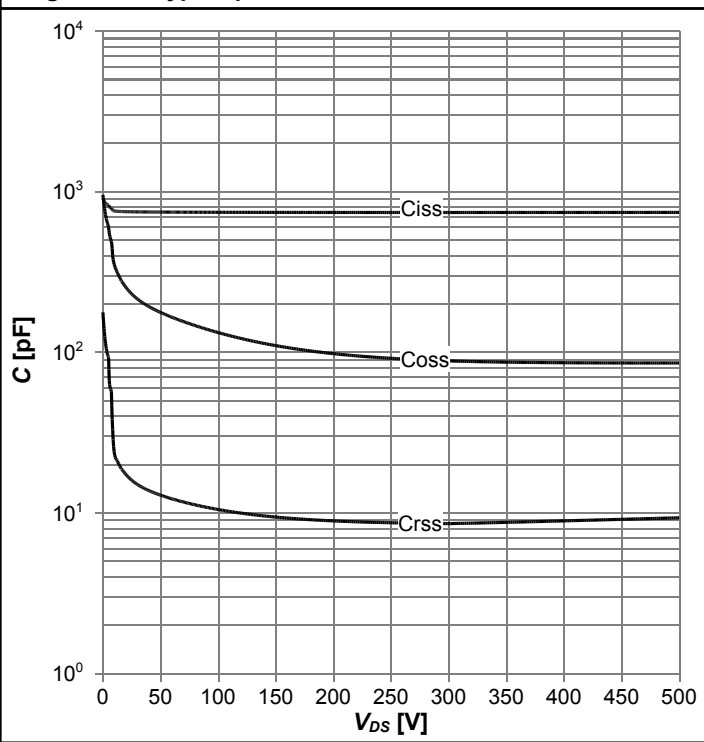
$E_{AS}=f(T_j); I_D=4.3 \text{ A}; V_{DD}=50 \text{ V}$

Diagram 14: Drain-source breakdown voltage



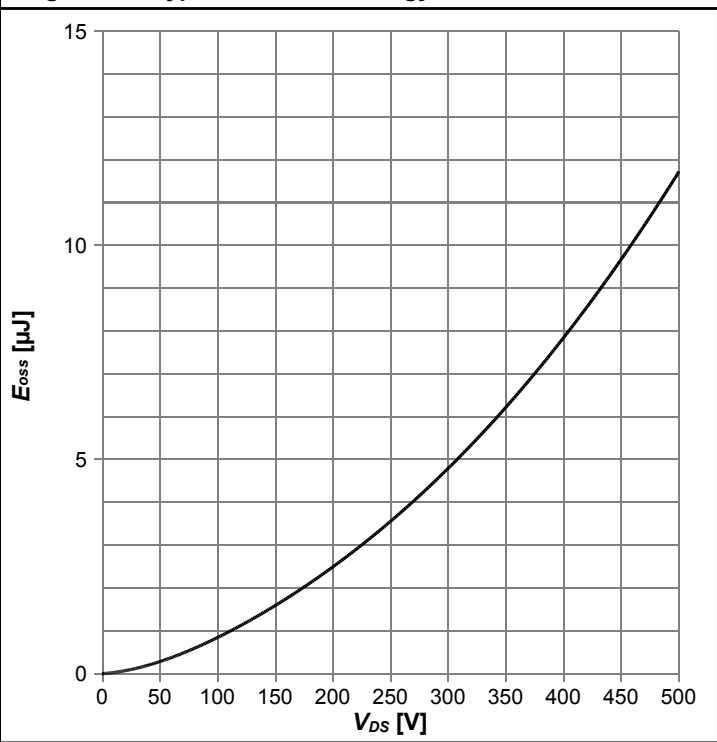
$V_{(BR)DSS}=f(T_j); I_D=0.4 \text{ mA}$

Diagram 15: Typ. capacitances

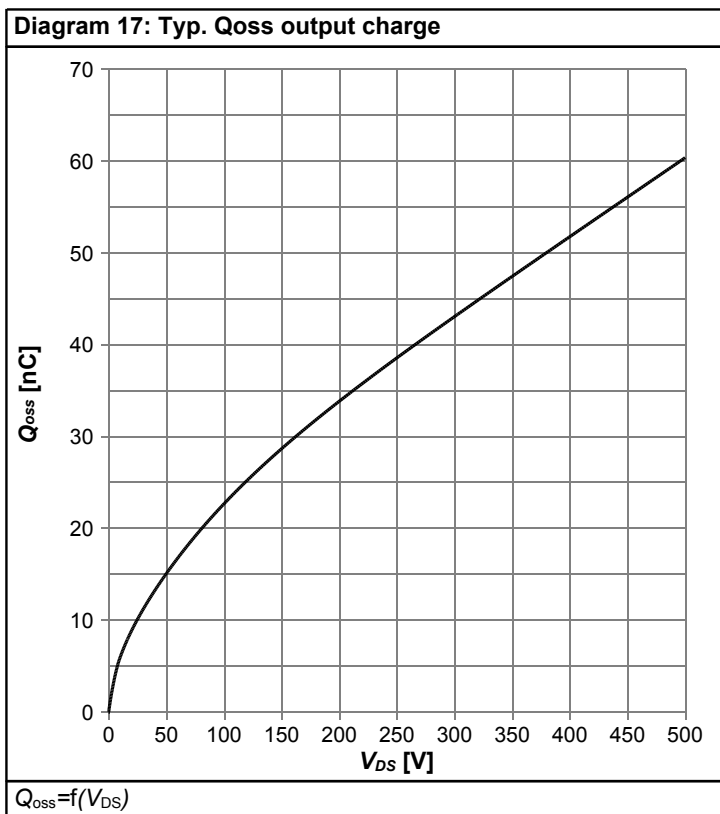


$C=f(V_{DS}); V_{GS}=0 \text{ V}; f=250 \text{ kHz}$

Diagram 16: Typ. Coss stored energy

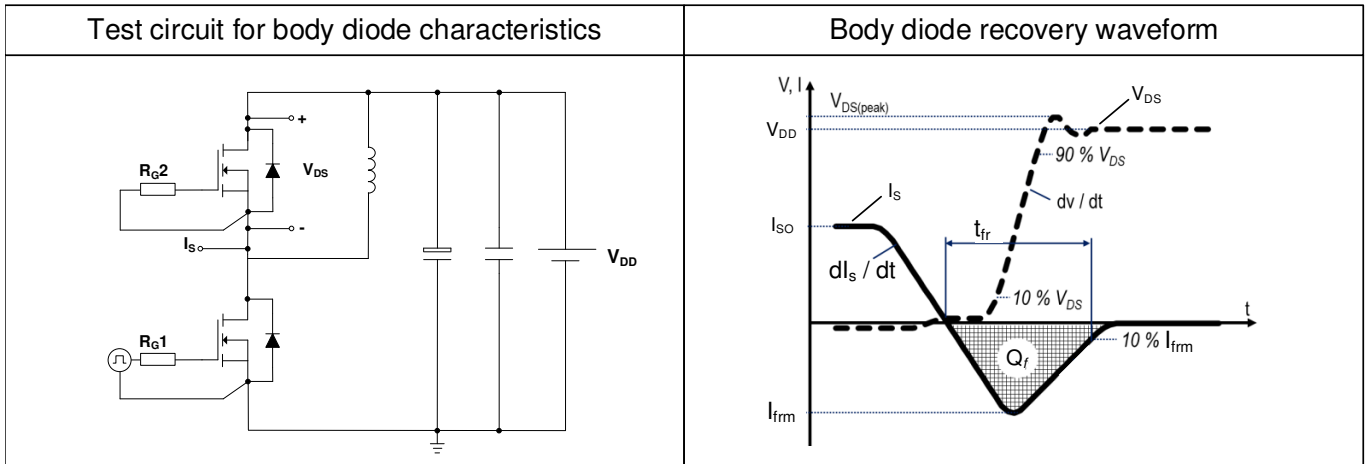


$E_{oss}=f(V_{DS})$

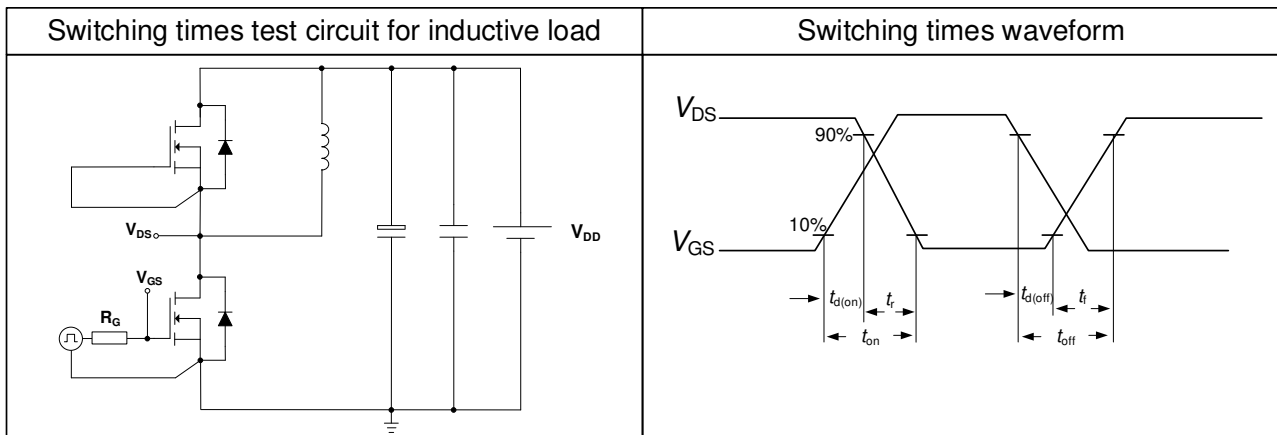


## 6 Test Circuits

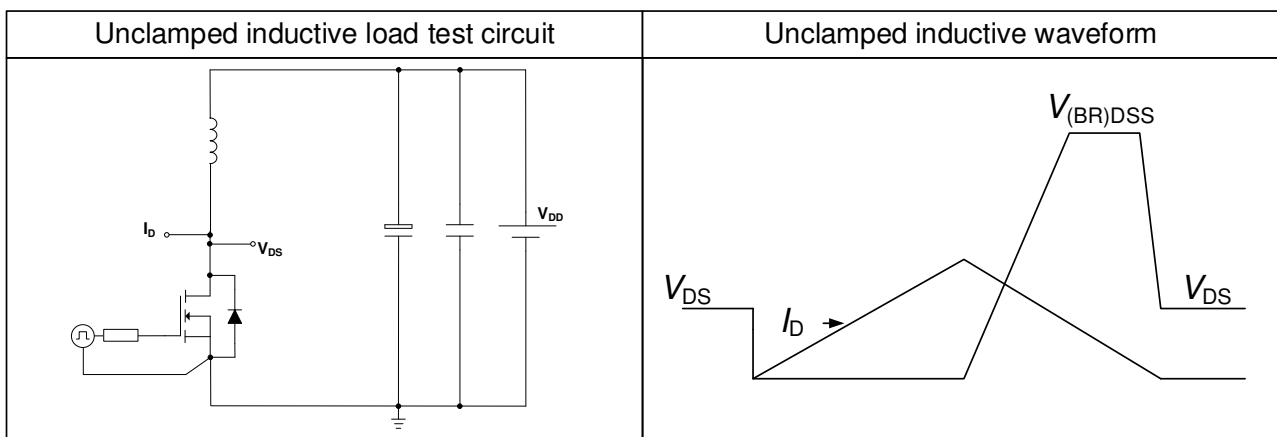
**Table 9 Body diode characteristics (650V CoolSiC)**



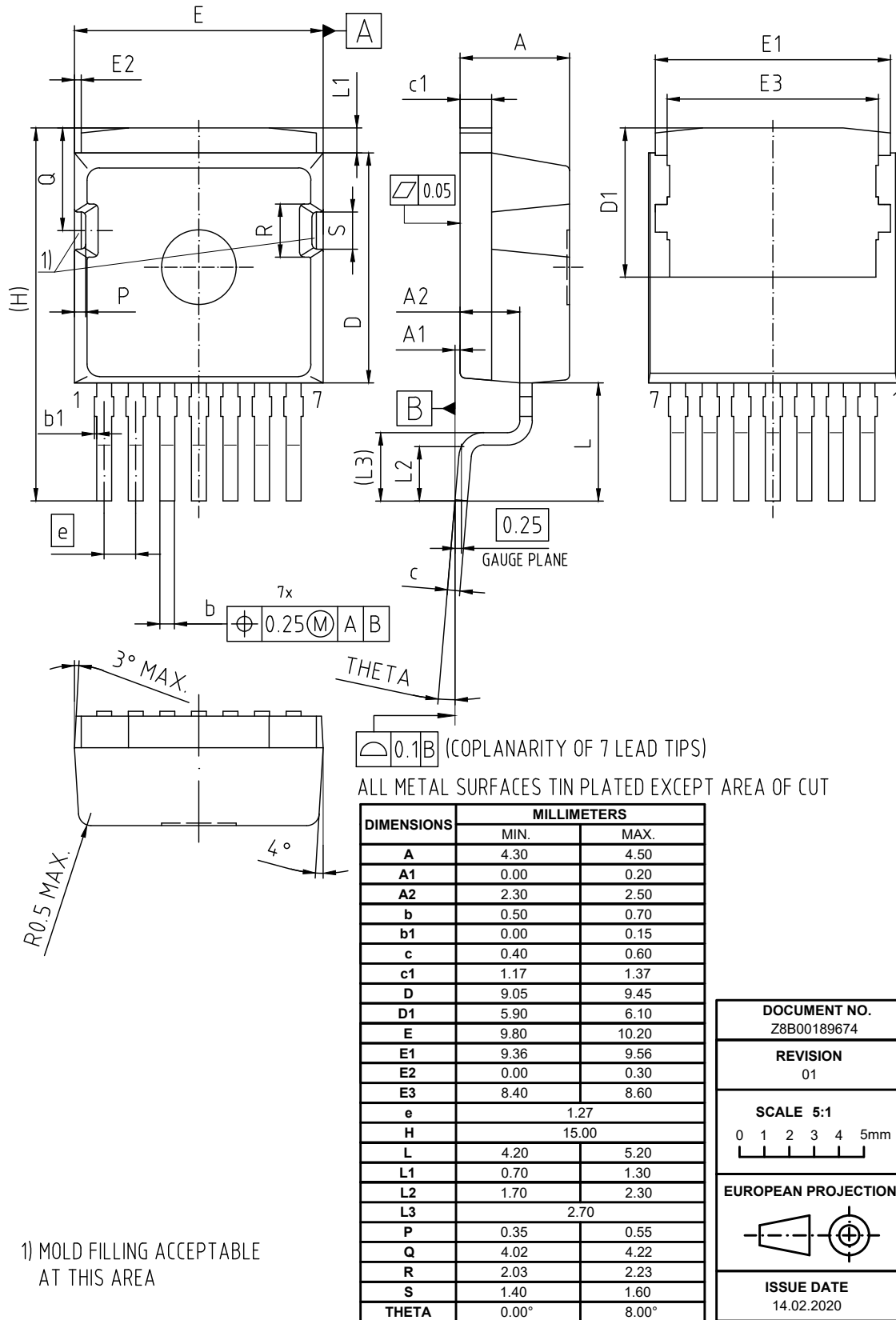
**Table 10 Switching times (650V CoolSiC)**



**Table 11 Unclamped inductive load (650V CoolSiC)**



**7 Package Outlines**



**Figure 1 Outline PG-T0263-7-12, dimensions in mm**

## 8 Appendix A

### Table 12 Related Links

- IFX CoolSiC M1 Webpage: [www.infineon.com](http://www.infineon.com)
- IFX CoolSiC M1 application note: [www.infineon.com](http://www.infineon.com)
- IFX CoolSiC M1 simulation model: [www.infineon.com](http://www.infineon.com)
- IFX Design tools: [www.infineon.com](http://www.infineon.com)

## Revision History

IMBG65R072M1H

**Revision: 2021-12-10, Rev. 2.0**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0      | 2021-12-10 | Release of final version                     |

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[C3M0120090J](#) [C3M0065090J](#) [C3M0280090J](#) [SCT2750NYTB](#) [SCT2H12NYTB](#) [C3M0021120D](#) [C3M0016120K](#) [C3M0045065D](#)  
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[DMWSH120H90SM4](#) [DMWSH120H90SM4Q](#) [DMWSH120H28SM4Q](#) [DMWSH120H90SCT7Q](#) [DMWSH120H28SM3](#)  
[DMWSH120H43SM3](#) [DMWSH120H90SM3](#) [DMWSH120H28SM3Q](#) [DMWSH120H90SM3Q](#) [DIF120SIC053-AQ](#) [DIW120SIC059-AQ](#)  
[G2R1000MT17D](#) [G3R60MT07K](#) [G2R50MT33K](#) [G3R12MT12K](#) [G3R160MT12D](#) [G3R160MT12J-TR](#) [G3R160MT17D](#) [G3R160MT17J-TR](#)  
[G3R20MT12K](#) [G3R20MT12N](#) [G3R20MT17K](#) [G3R20MT17N](#) [G3R30MT12J-TR](#) [G3R30MT12K](#) [G3R350MT12D](#) [G3R40MT12D](#)  
[G3R40MT12J](#)