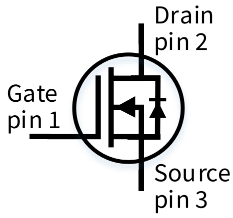
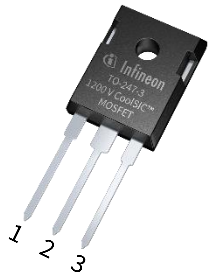
# IMW120R045M1

## CoolSiC™ 1200V SiC Trench MOSFET
## Silicon Carbide MOSFET

### Features




- Very low switching losses
- Threshold-free on state characteristic
- Wide gate-source voltage range
- Benchmark gate threshold voltage, $V_{GS(th)}$ = 4.5V
- 0V turn-off gate voltage
- Fully controllable dV/dt
- Commutation robust body diode, ready for synchronous rectification
- Temperature independent turn-off switching losses




### Benefits

- Efficiency improvement
- Enabling higher frequency
- Increased power density
- Cooling effort reduction
- Reduction of system complexity and cost

### Potential applications

- Energy generation
  - Solar string inverter and solar optimizer
- Industrial power supplies
  - Industrial UPS
  - Industrial SMPS
- Infrastructure – Charge
  - Charger

### Product validation

Qualified for industrial applications according to the relevant tests of JEDEC 47/20/22

**Table 1 Key Performance and Package Parameters**

| Type | $V_{DS}$ | $I_D$ ($T_C$ = 25°C, $R_{th(j-c,max)}$) | $R_{DS(on)}$ ($T_{vj}$ = 25°C, $I_D$ = 20A, $V_{GS}$ = 15V) | $T_{j,max}$ | Marking | Package |
|---|---|---|---|---|---|---|
| IMW120R045M1 | 1200V | 52A | 45mΩ | 175°C | 12M1045 | PG-TO247-3 |

# Table of contents

# 1 Maximum ratings

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

**Table 2 Maximum ratings**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Drain-source voltage, $T_{vj} \geq 25°C$ | $V_{DSS}$ | 1200 | V |
| DC drain current for $R_{th(j-c,max)}$, limited by $T_{vjmax}$, $V_{GS} = 15V$,<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_D$ | <br>52<br>36 | A |
| Pulsed drain current, $t_p$ limited by $T_{vjmax}$, $V_{GS} = 15V$ | $I_{D,pulse}$[1] | 130 | A |
| DC body diode forward current for $R_{th(j-c,max)}$,<br>limited by $T_{vjmax}$, $V_{GS} = 0V$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $I_{SD}$ | <br><br>52<br>28 | A |
| Pulsed body diode current, $t_p$ limited by $T_{vjmax}$ | $I_{SD,pulse}$[1] | 130 | A |
| Gate-source voltage[2]<br>Max transient voltage, < 1% duty cycle<br>Recommended turn-on gate voltage<br>Recommended turn-off gate voltage | <br>$V_{GSS}$<br>$V_{GSS,on}$<br>$V_{GSS,off}$ | <br>-10… 20<br>15<br>0 | V |
| Power dissipation, limited by $T_{vjmax}$<br>$T_C = 25°C$<br>$T_C = 100°C$ | $P_{tot}$ | <br>228<br>114 | W |
| Virtual junction temperature | $T_{vj}$ | -55… 175 | °C |
| Storage temperature | $T_{stg}$ | -55… 150 | °C |
| Soldering temperature,<br>wavesoldering only allowed at leads,<br>1.6mm (0.063 in.) from case for 10 s | $T_{sold}$ | 260 | °C |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3 | $M$ | 0.6 | Nm |

[1] verified by design
[2] **Important note:** The selection of positive and negative gate-source voltages impacts the long-term behavior of the device. The design guidelines described in Application Note *AN2018-09* must be considered to ensure sound operation of the device over the planned lifetime.

# 2 Thermal resistances

**Table 3**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| MOSFET/body diode thermal resistance, junction – case | $R_{th(j-c)}$ | | - | 0.51 | 0.66 | K/W |
| Thermal resistance, junction – ambient | $R_{th(j-a)}$ | leaded | - | - | 62 | K/W |

# 3 Electrical Characteristics

## 3.1 Static characteristics

**Table 4 Static characteristics (at $T_{vj}$ = 25°C, unless otherwise specified)**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}$ = 15V, $I_D$ = 20A, | | | | mΩ |
| | | $T_{vj}$ = 25°C | - | 45 | 59 | |
| | | $T_{vj}$ = 100°C | - | 55 | - | |
| | | $T_{vj}$ = 175°C | - | 75 | - | |
| Body diode forward voltage | $V_{SD}$ | $V_{GS}$ = 0V, $I_{SD}$ = 20A | | | | V |
| | | $T_{vj}$ = 25°C | - | 4.1 | 5.2 | |
| | | $T_{vj}$ = 100°C | - | 4.0 | - | |
| | | $T_{vj}$ = 175°C | - | 3.9 | - | |
| Gate-source threshold voltage | $V_{GS(th)}$ | *(tested after 1 ms pulse at $V_{GS}$ = 20V)* | | | | V |
| | | $I_D$ = 10mA, $V_{DS}$ = $V_{GS}$ | | | | |
| | | $T_{vj}$ = 25°C | 3.5 | 4.5 | 5.7 | |
| | | $T_{vj}$ =175°C | - | 3.6 | - | |
| Zero gate voltage drain current | $I_{DSS}$ | $V_{GS}$ = 0V, $V_{DS}$ = 1200V | | | | µA |
| | | $T_{vj}$=25°C | - | 2 | 200 | |
| | | $T_{vj}$=175°C | - | 4 | - | |
| Gate-source leakage current | $I_{GSS}$ | $V_{GS}$ = 20V, $V_{DS}$ = 0V | - | - | 120 | nA |
| | | $V_{GS}$ = -10V, $V_{DS}$ = 0V | - | - | -120 | nA |
| Transconductance | $g_{fs}$ | $V_{DS}$ = 20V, $I_D$ = 20A | - | 11.1 | - | S |
| Internal gate resistance | $R_{G,int}$ | $f$ = 1MHz, $V_{AC}$ = 25mV | - | 4 | - | Ω |

## 3.2 Dynamic characteristics

**Table 5 Dynamic characteristics (at $T_{vj}$ = 25°C, unless otherwise specified)**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| Input capacitance | $C_{iss}$ | $V_{DD}$ = 800V, $V_{GS}$ = 0V, $f$ = 1MHz, $V_{AC}$ = 25mV | - | 1900 | - | pF |
| Output capacitance | $C_{oss}$ | | - | 115 | - | pF |
| Reverse capacitance | $C_{rss}$ | | - | 13 | - | pF |
| $C_{oss}$ stored energy | $E_{oss}$ | | - | 44 | - | µJ |
| Total gate charge | $Q_G$ | $V_{DD}$ = 800V, $I_D$ = 20A, $V_{GS}$ = 0/15V, turn-on pulse | - | 52 | - | nC |
| Gate to source charge | $Q_{GS,pl}$ | | - | 15 | - | nC |
| Gate to drain charge | $Q_{GD}$ | | - | 13 | - | nC |
| Short-circuit withstand time[3] | $t_{SC}$ | $V_{DD}$ = 800V, $L_σ$ = 80nH, $R_{G,ext}$ = 8Ohm, $T_{vj}$ = 175°C, $V_{GS.on}$ = 15V | - | 3 | - | µs |

[3] Verified by design for single short circuit event at $V_{GS,on}$ = 15V.

## 3.3 Switching characteristics

**Table 6 Switching characteristics, Inductive load [4]**

| Parameter | Symbol | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| **MOSFET Characteristics, $T_{vj}$ = 25°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = 800V, $I_D$ = 20A, $V_{GS}$ = 0/15V, $R_{G,ext}$ = 2Ω, $L_\sigma$ = 40nH, diode: body diode at $V_{GS}$ = 0V see Fig. E | - | 9 | - | ns |
| Rise time | $t_r$ | | - | 24 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 17 | - | |
| Fall time | $t_f$ | | - | 13 | - | |
| Turn-on energy | $E_{on}$ | | - | 350 | - | µJ |
| Turn-off energy | $E_{off}$ | | - | 70 | - | |
| Total switching energy | $E_{tot}$ | | - | 420 | - | |
| **Body Diode Characteristics, $T_{vj}$ = 25°C** | | | | | | |
| Diode reverse recovery charge | $Q_{rr}$ | $V_{DD}$ = 800V, $I_{SD}$ = 20A, $V_{GS}$ at diode = 0V, $di_f/dt$ = 1000A/µs, $Q_{rr}$ includes also $Q_C$, see Fig. C | - | 0.15 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 8 | - | A |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MOSFET Characteristics, $T_{vj}$ = 175°C** | | | | | | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = 800V, $I_D$ = 20A, $V_{GS}$ = 0/15V, $R_{G,ext}$ = 2Ω, $L_\sigma$ = 40nH, diode: body diode at $V_{GS}$ = 0V see Fig. E | - | 9 | - | ns |
| Rise time | $t_r$ | | - | 24 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 20 | - | |
| Fall time | $t_f$ | | - | 14 | - | |
| Turn-on energy | $E_{on}$ | | - | 380 | - | µJ |
| Turn-off energy | $E_{off}$ | | - | 75 | - | |
| Total switching energy | $E_{tot}$ | | - | 455 | - | |
| **Body Diode Characteristics, $T_{vj}$ = 175°C** | | | | | | |
| Diode reverse recovery charge | $Q_{rr}$ | $V_{DD}$ = 800V, $I_{SD}$ = 20A, $V_{GS}$ at diode = 0V, $di_f/dt$ = 1000A/µs, $Q_{rr}$ includes also $Q_C$, see Fig. C | - | 0.25 | - | µC |
| Diode peak reverse recovery current | $I_{rrm}$ | | - | 10 | - | A |

[4] The chip technology was characterized up to 200 kV/µs. The measured dV/dt was limited by measurement test setup and package.

# 4 Electrical characteristic diagrams

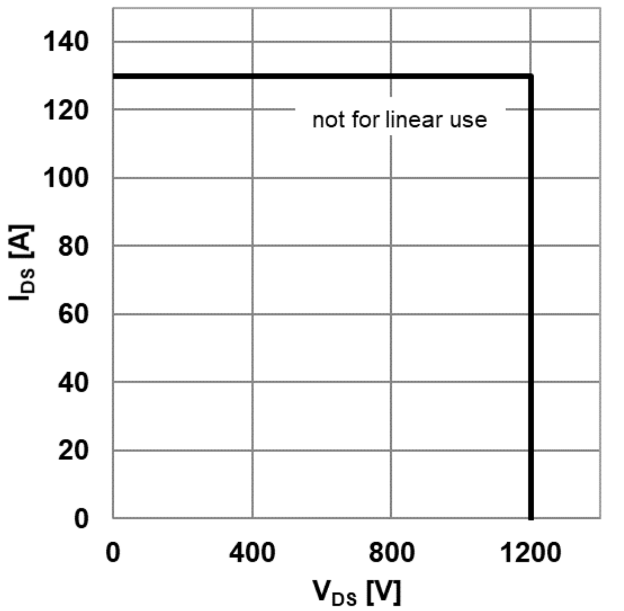



**Figure 1** **Reverse bias safe operating area (RBSOA)** ($V_{gs}$ = 0/15V, $T_c$ = 25°C, $T_j$ < 175°C)

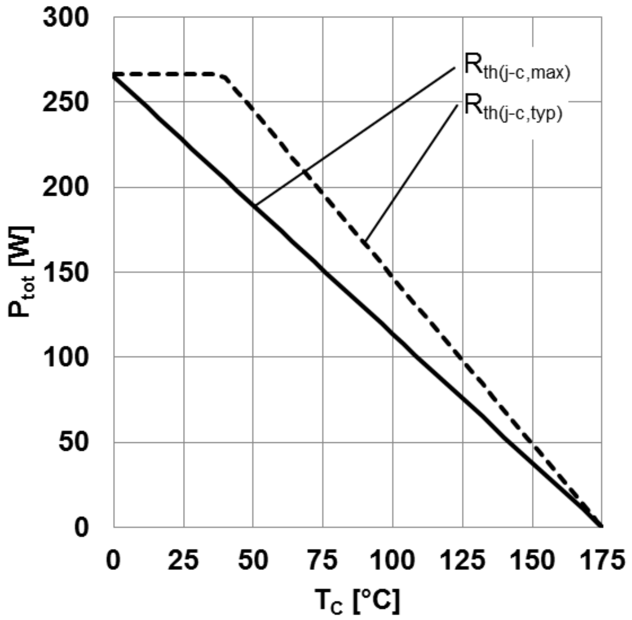



**Figure 2** **Power dissipation as a function of case temperature limited by bond wire** ($P_{tot}$ = f($T_C$))

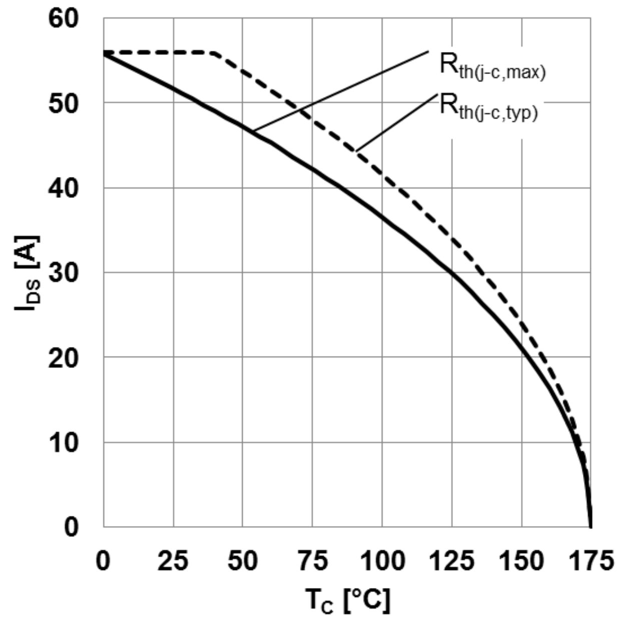



**Figure 3** **Maximum DC drain to source current as a function of case temperature limited by bond wire** ($I_{DS}$ = f($T_C$))

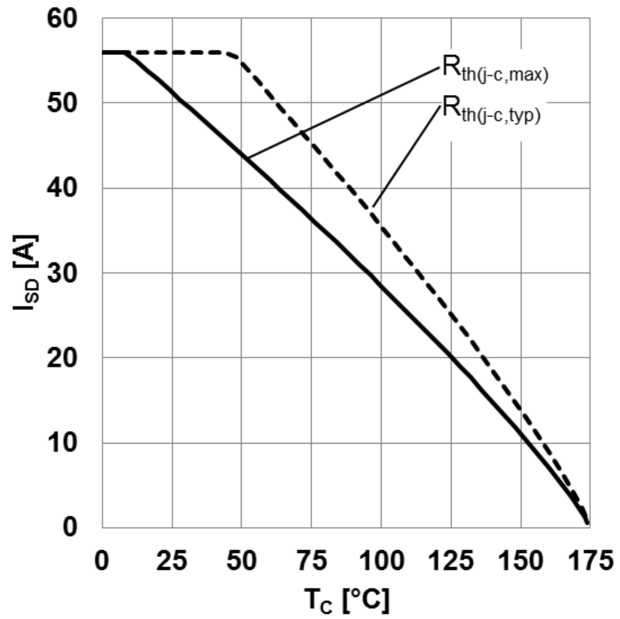



**Figure 4** **Maximum source to drain current as a function of case temperature limited by bond wire** ($I_{SD}$ = f($T_C$), $V_{GS}$ = 0V)

**Electrical characteristic diagrams**

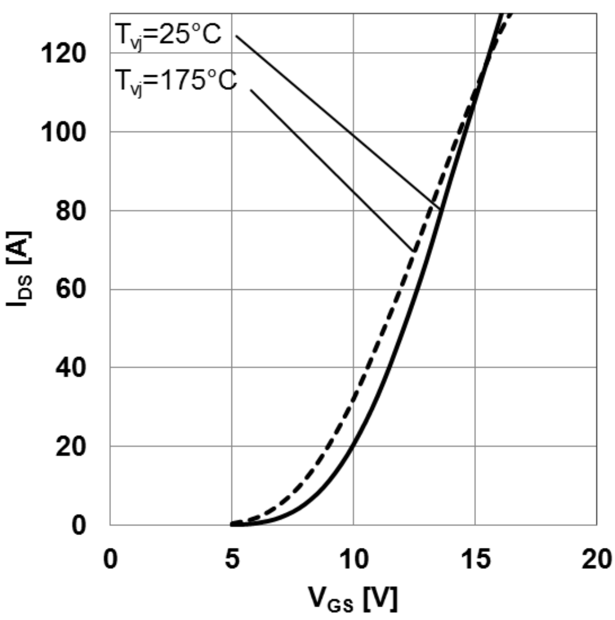



**Figure 5** **Typical transfer characteristic**
($I_{DS}$ = f($V_{GS}$), $V_{DS}$ = 20V, $t_P$ = 20µs)

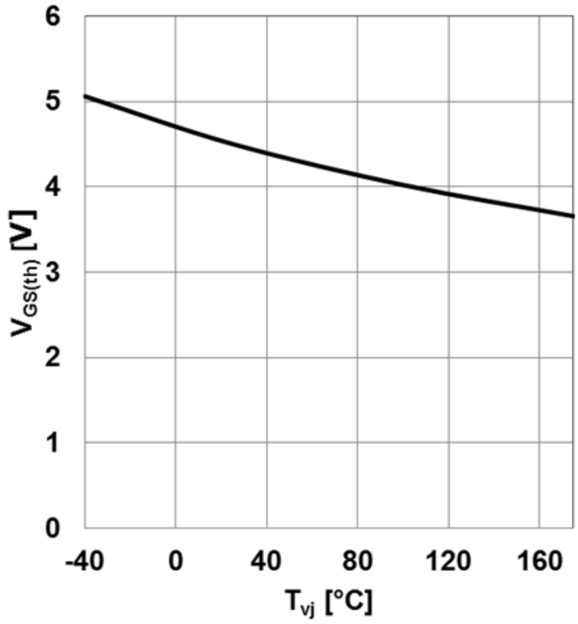



**Figure 6** **Typical gate-source threshold voltage as a function of junction temperature**
($V_{GS(th)}$ = f($T_{vj}$), $I_{DS}$ = 10mA, $V_{GS}$ = $V_{DS}$)

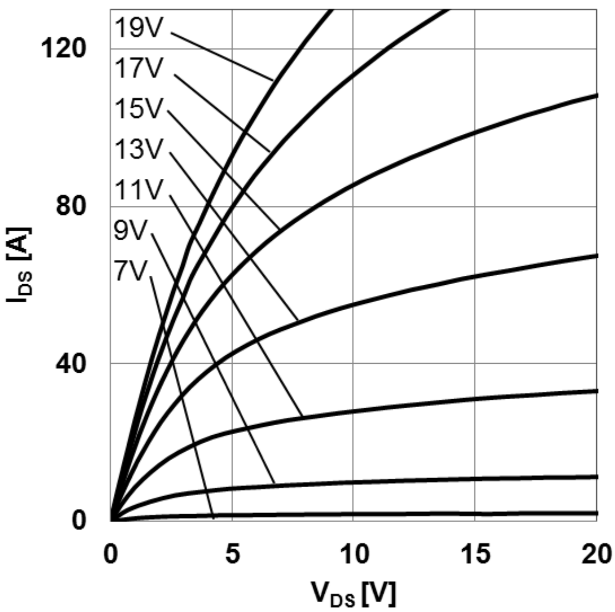



**Figure 7** **Typical output characteristic, $V_{GS}$ as parameter** ($I_{DS}$ = f($V_{DS}$), $T_{vj}$=25°C, $t_P$ = 20µs)

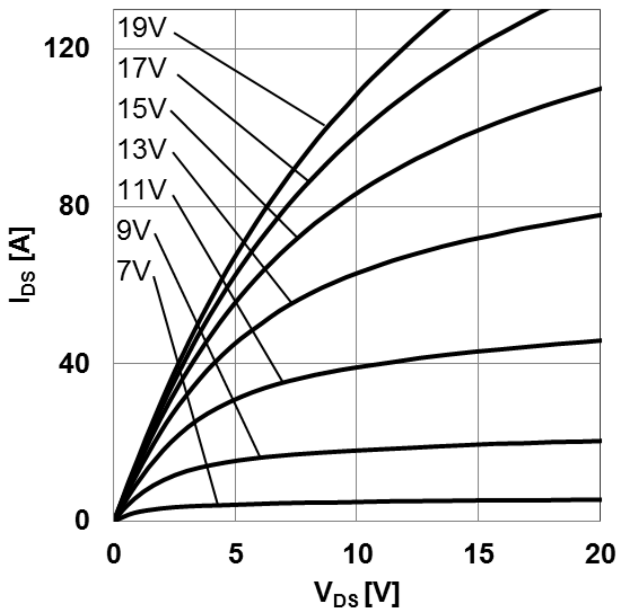



**Figure 8** **Typical output characteristic, $V_{GS}$ as parameter** ($I_{DS}$ = f($V_{DS}$), $T_{vj}$=175°C, $t_P$ = 20µs)

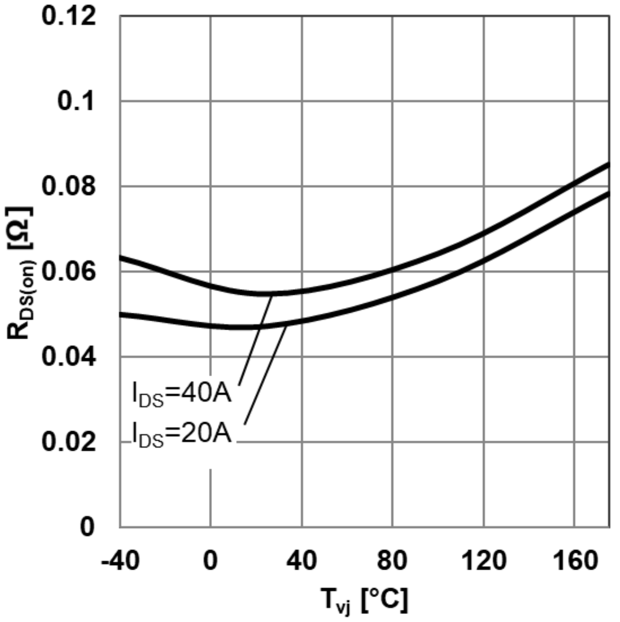



**Figure 9** **Typical on-resistance as a function of junction temperature**
($R_{DS(on)}$ = f($T_{vj}$), $V_{GS}$=15V)

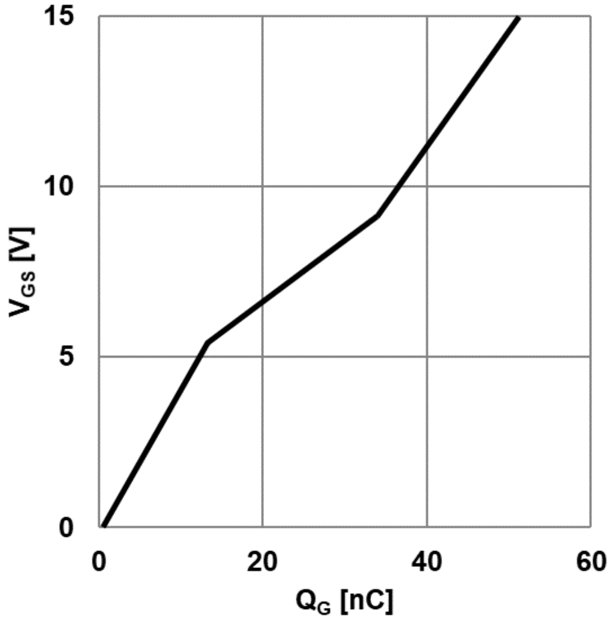



**Figure 10** **Typical gate charge** ($V_{GS}$ = f($Q_G$), $I_{DS}$ = 20A, $V_{DS}$ = 800V, turn-on pulse)

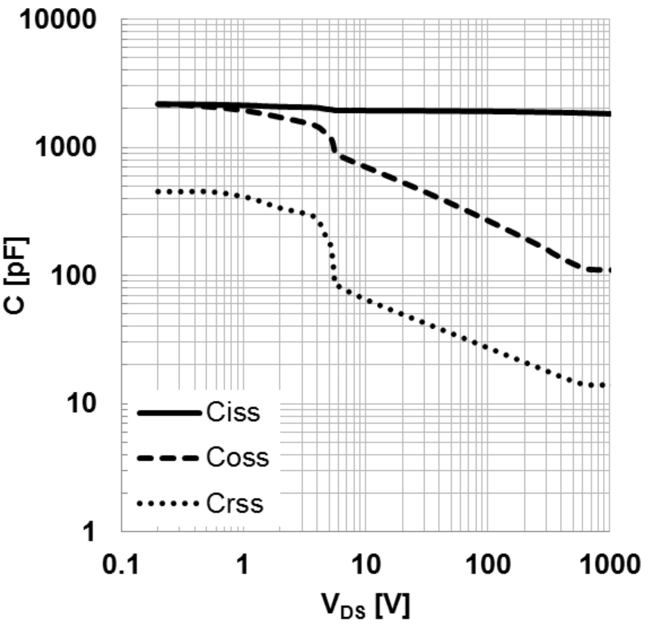



**Figure 11** **Typical capacitance as a function of drain-source voltage**
($C$ = f($V_{DS}$), $V_{GS}$ = 0V, $f$ = 1MHz)

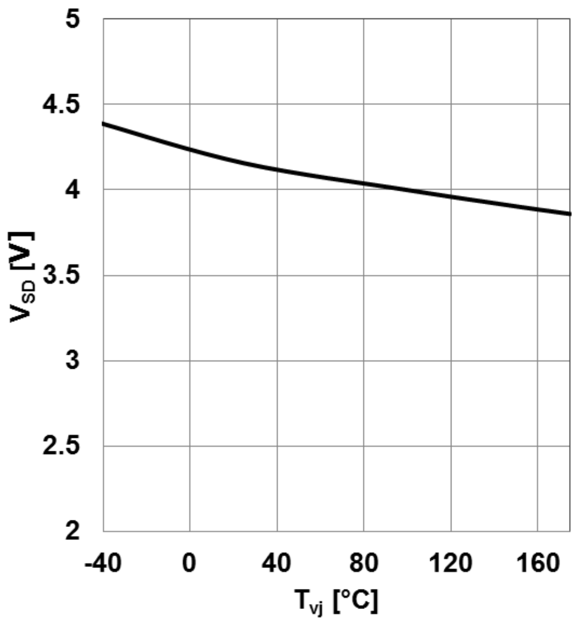



**Figure 12** **Typical body diode forward voltage as function of junction temperature**
($V_{SD}$=f($T_{vj}$), $V_{GS}$=0V, $I_{SD}$=20A)

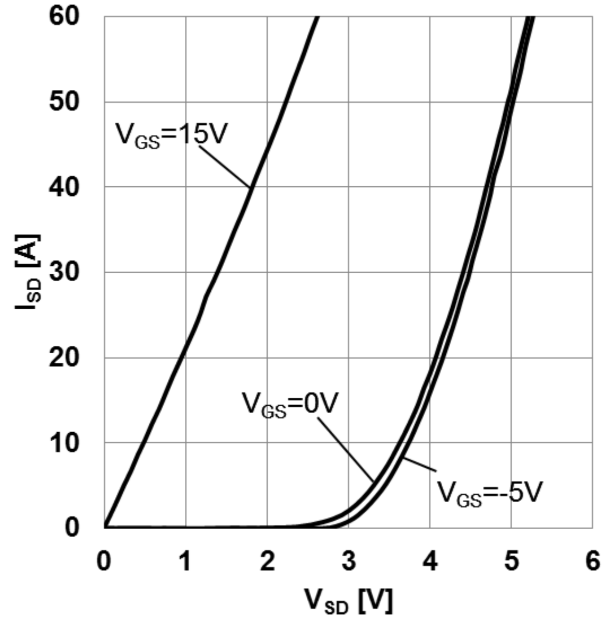



**Figure 13** **Typical body diode forward current as function of forward voltage, $V_{GS}$ as parameter**
($I_{SD}$ = f($V_{SD}$), $T_{vj}$ = 25°C, $t_P$ = 20µs)

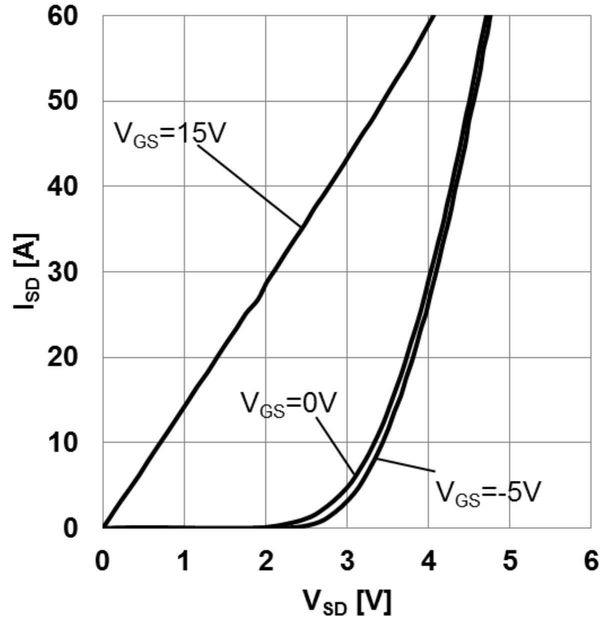



**Figure 14** **Typical body diode forward current as function of forward voltage, $V_{GS}$ as parameter**
($I_{SD}$ = f($V_{SD}$), $T_{vj}$ = 175°C, $t_P$ = 20µs)

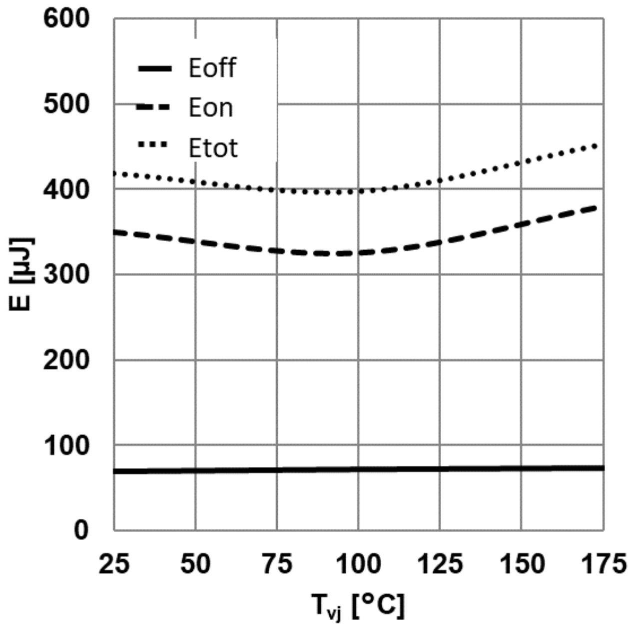



**Figure 15** **Typical switching energy losses as a function of junction temperature**
($E$ = f($T_{vj}$), $V_{DD}$ = 800V, $V_{GS}$ = 0V/15V, $R_{G,ext}$ = 2Ω, $I_D$ = 20A, ind. load, test circuit in Fig. E, diode: body diode)

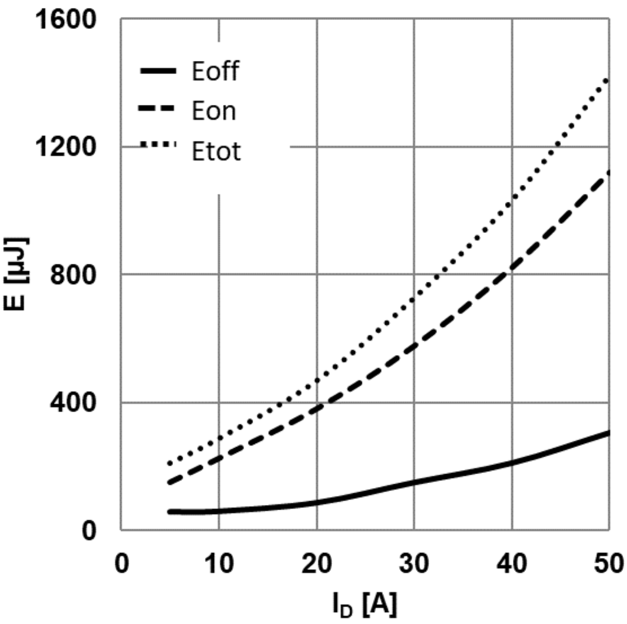



**Figure 16** **Typical switching energy losses as a function of drain-source current**
($E$ = f($I_{DS}$), $V_{DD}$ = 800V, $V_{GS}$ = 0V/15V, $R_{G,ext}$ = 2Ω, $T_{vj}$ = 175°C, ind. load, test circuit in Fig. E, diode: body diode)

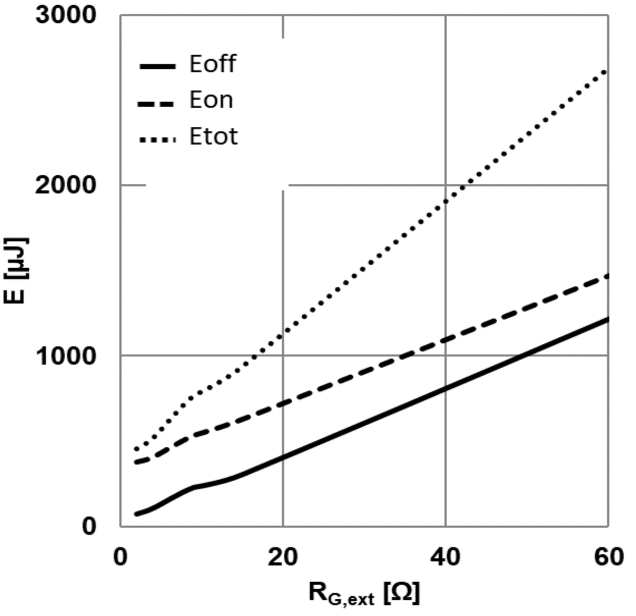



**Figure 17** **Typical switching energy losses as a function of gate resistance**
($E$ = f($R_{G,ext}$), $V_{DD}$ = 800V, $V_{GS}$ = 0V/15V, $I_D$ = 20A, $T_{vj}$ = 175°C, ind. load, test circuit in Fig. E, diode: body diode)

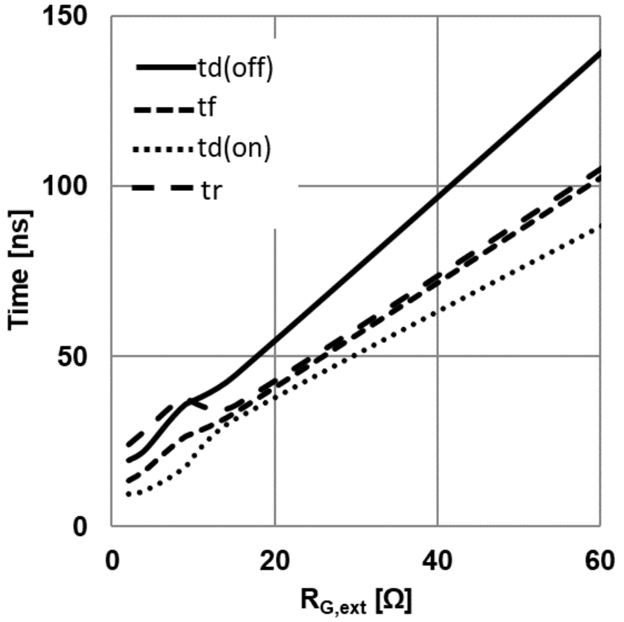



**Figure 18** **Typical switching times as a function of gate resistor**
($t$ = f($R_{G,ext}$), $V_{DD}$ = 800V, $V_{GS}$ = 0V/15V, $I_D$ = 20A, $T_{vj}$ = 175°C, ind. load, test circuit in Fig. E, diode: body diode)

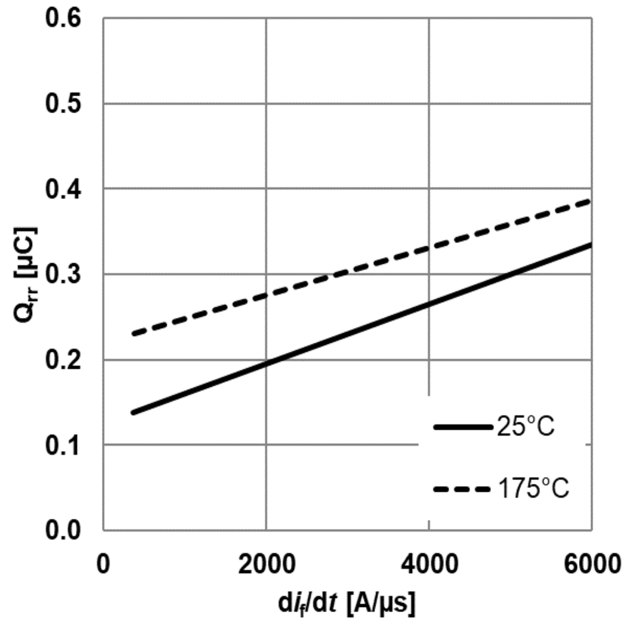



**Figure 19** **Typical reverse recovery charge as a function of diode current slope**
($Q_{rr}$ = f($di_f/dt$), $V_{DD}$ = 800V, $I_D$ = 20A, ind. load, test circuit in Fig.E)

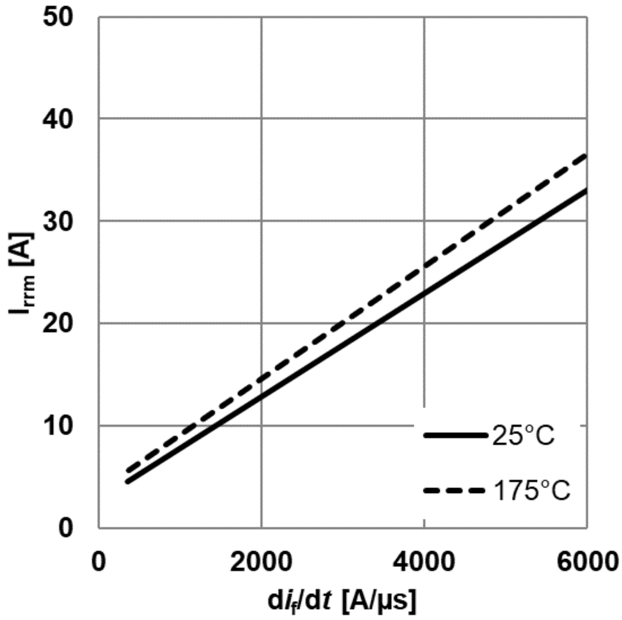



**Figure 20** **Typical reverse recovery current as a function of diode current slope**
($I_{rrm}$ = f($di_f/dt$), $V_{DD}$ = 800V, $I_D$ = 20A, ind. load, test circuit in Fig.E)

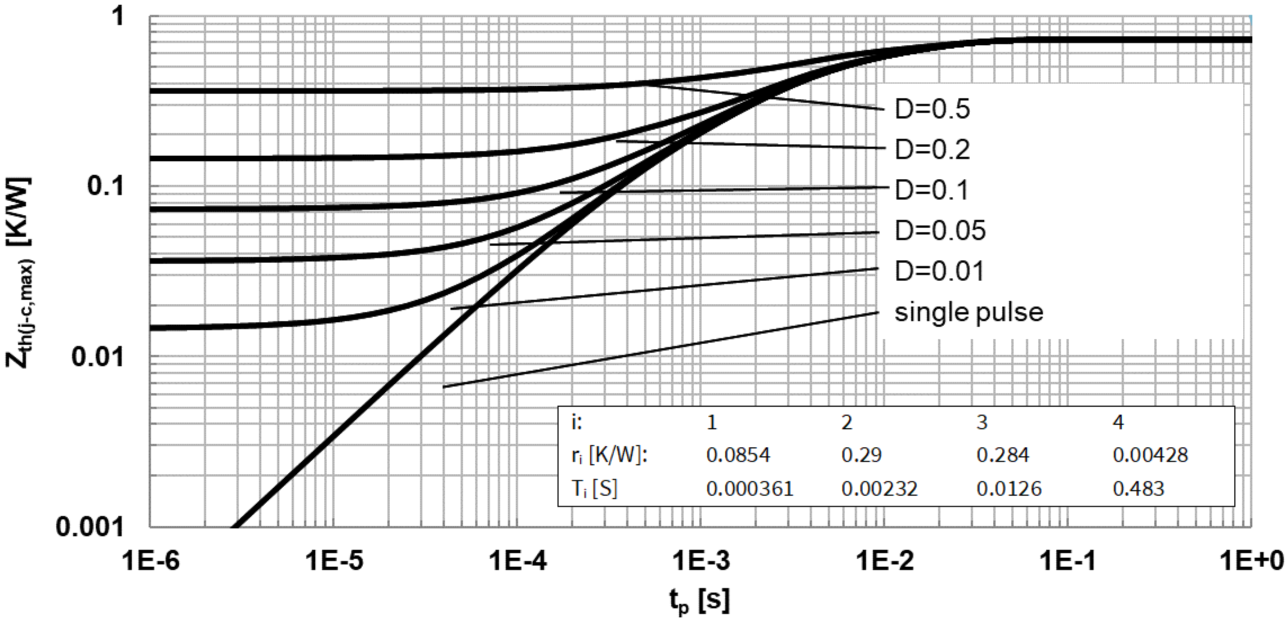
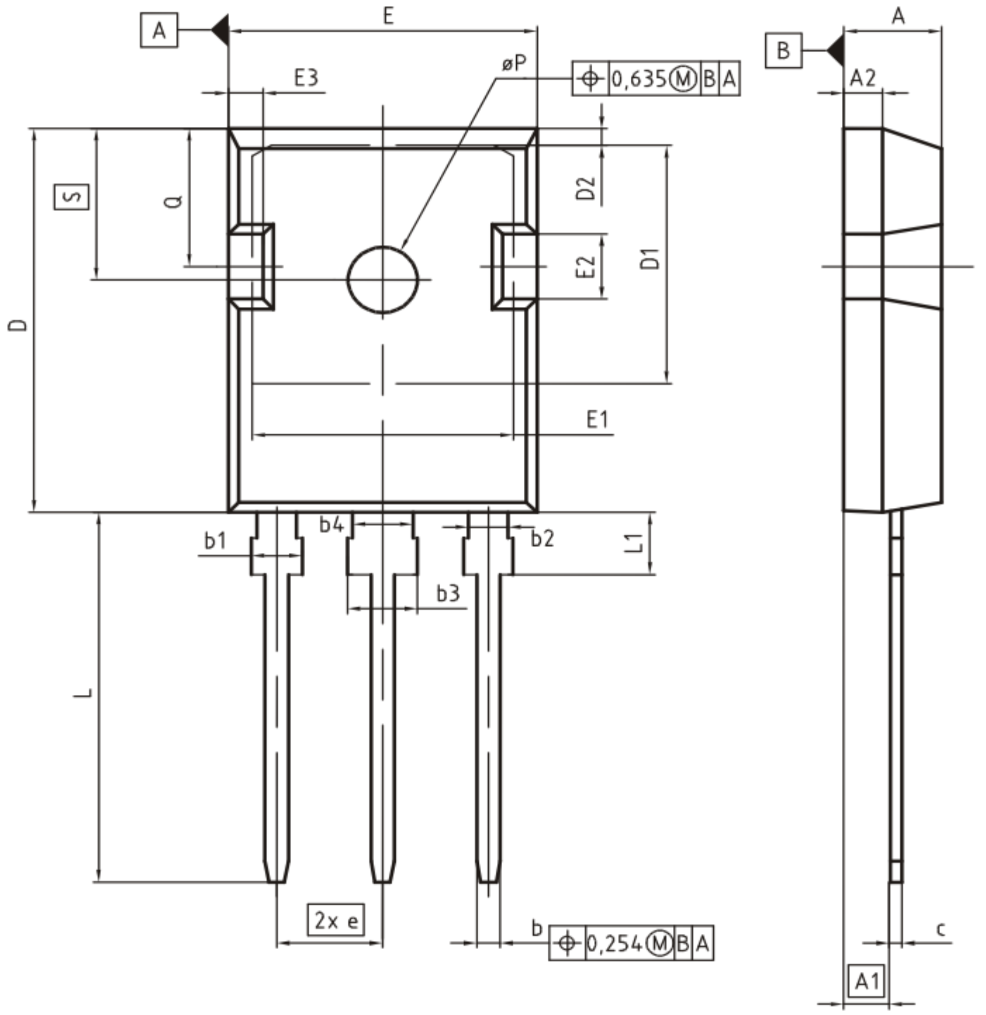



**Figure 21 Max. transient thermal resistance (MOSFET/diode)**
($Z_{th(j\text{-}c,max)} = f(t_P)$, parameter $D = t_p/T$, thermal equivalent circuit in Fig. D)

# 5 Package drawing

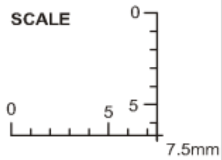
PG-TO247-3



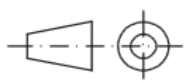

| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 4.83 | 5.21 | 0.190 | 0.205 |
| A1 | 2.27 | 2.54 | 0.089 | 0.100 |
| A2 | 1.85 | 2.16 | 0.073 | 0.085 |
| b | 1.07 | 1.33 | 0.042 | 0.052 |
| b1 | 1.90 | 2.41 | 0.075 | 0.095 |
| b2 | 1.90 | 2.16 | 0.075 | 0.085 |
| b3 | 2.87 | 3.38 | 0.113 | 0.133 |
| b4 | 2.87 | 3.13 | 0.113 | 0.123 |
| c | 0.55 | 0.68 | 0.022 | 0.027 |
| D | 20.80 | 21.10 | 0.819 | 0.831 |
| D1 | 16.25 | 17.65 | 0.640 | 0.695 |
| D2 | 0.95 | 1.35 | 0.037 | 0.053 |
| E | 15.70 | 16.13 | 0.618 | 0.635 |
| E1 | 13.10 | 14.15 | 0.516 | 0.557 |
| E2 | 3.68 | 5.10 | 0.145 | 0.201 |
| E3 | 1.00 | 2.60 | 0.039 | 0.102 |
| e | 5.44 (BSC) | | 0.214 (BSC) | |
| N | 3 | | 3 | |
| L | 19.80 | 20.32 | 0.780 | 0.800 |
| L1 | 4.10 | 4.47 | 0.161 | 0.176 |
| øP | 3.50 | 3.70 | 0.138 | 0.146 |
| Q | 5.49 | 6.00 | 0.216 | 0.236 |
| S | 6.04 | 6.30 | 0.238 | 0.248 |

**DOCUMENT NO.**
Z8B00003327

**SCALE** 0 5 7.5mm



**EUROPEAN PROJECTION**



**ISSUE DATE**
09-07-2010

**REVISION**
05

**Figure 22** **Package drawing**

# 6 Test conditions

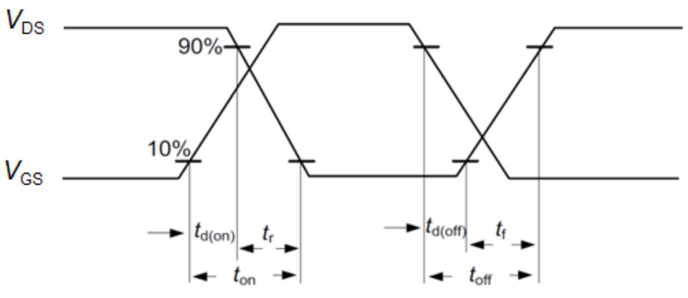



Figure A. **Definition of switching times**

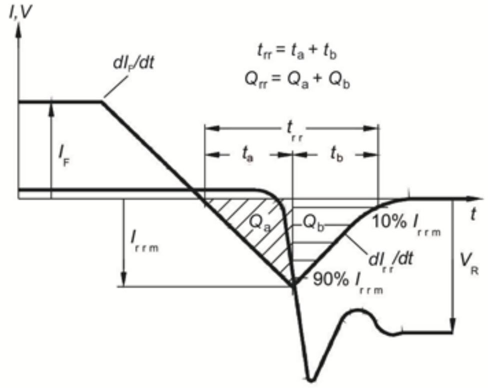



Figure C. **Definition of diode switching characteristics**

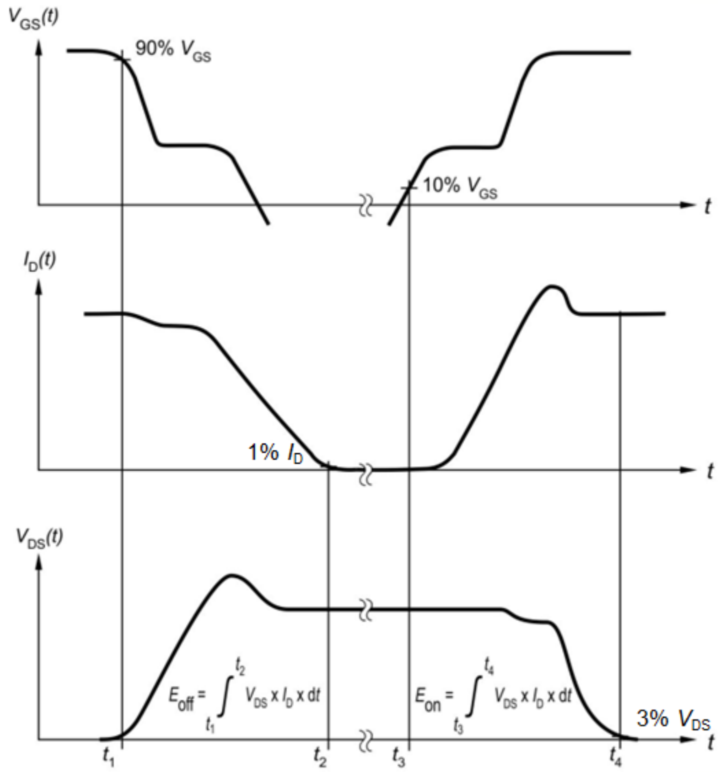



Figure B. **Definition of switching losses**

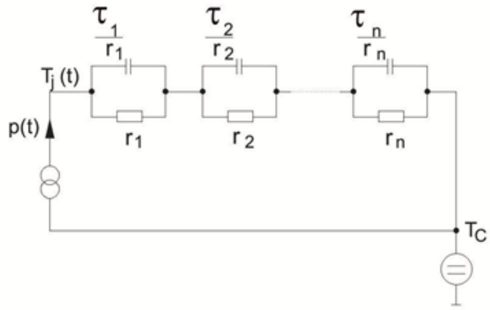



Figure D. **Thermal equivalent circuit**

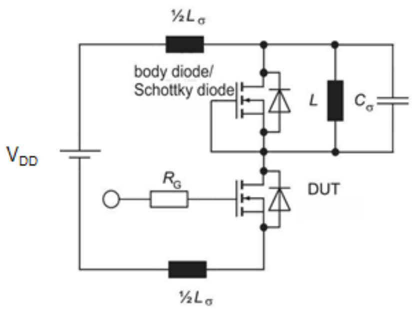



Figure E. **Dynamic test circuit**

Parasitic inductance $L_{\sigma}$,

parasitic capacitor $C_{\sigma}$,

**Figure 23** **Test conditions**

# Revision history

### Major changes since the last revision

| Document version | Date of release | Description of changes |
|---|---|---|
| 2.1 | 2018-03-01 | Initial version |
| 2.2 | 2018-05-30 | Important footnote update in chapter 1<br>Change of conditions for switching dynamic characteristics in chapter 3.2 and 3.3<br>Additional figures for $V_{GS}$=0V/15V in chapter 4 |
| 2.3 | 2019-04-18 | Add Recommended gate voltage in chapter 1<br>Add SOA figure in chapter 4<br>Figures removed for $V_{GS}$=-5V/15V in chapter 4 |

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**Published by**

**Infineon Technologies AG**

**81726 München, Germany**