

# IMW120R045M1

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

### Features

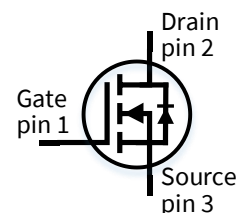
- Very low switching losses
- Threshold-free on state characteristic
- Wide gate-source voltage range
- Benchmark gate threshold voltage,  $V_{GS(th)} = 4.5V$
- 0V turn-off gate voltage
- Fully controllable dv/dt
- Commutation robust body diode, ready for synchronous rectification
- Temperature independent 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         | $V_{DS}$ | $I_D$<br>( $T_C = 25^\circ C, R_{th(j-c,max)}$ ) | $R_{DS(on)}$<br>( $T_{vj} = 25^\circ C, I_D = 20A, V_{GS} = 15V$ ) | $T_{j,max}$ | Marking  | Package    |
|--------------|----------|--------------------------------------------------|--------------------------------------------------------------------|-------------|----------|------------|
| IMW120R045M1 | 1200V    | 52A                                              | 45mΩ                                                               | 175°C       | 120M1045 | PG-TO247-3 |

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## Maximum ratings

# 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, $T_{vj} \geq 25^{\circ}\text{C}$                                                                                                              | $V_{DSS}$                                  | 1200                 | V                  |
| DC drain current for $R_{th(j-c,max)}$ , limited by $T_{vjmax}$ , $V_{GS} = 15\text{V}$ ,<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$              | $I_D$                                      | 52<br>36             | A                  |
| Pulsed drain current, $t_p$ limited by $T_{vjmax}$ , $V_{GS} = 15\text{V}$                                                                                          | $I_{D,pulse}^1$                            | 130                  | A                  |
| DC body diode forward current for $R_{th(j-c,max)}$ ,<br>limited by $T_{vjmax}$ , $V_{GS} = 0\text{V}$<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$ | $I_{SD}$                                   | 52<br>28             | A                  |
| Pulsed body diode current, $t_p$ limited by $T_{vjmax}$                                                                                                             | $I_{SD,pulse}^1$                           | 130                  | A                  |
| Gate-source voltage <sup>2</sup><br>Max transient voltage, < 1% duty cycle<br>Recommended turn-on gate voltage<br>Recommended turn-off gate voltage                 | $V_{GSS}$<br>$V_{GSS,on}$<br>$V_{GSS,off}$ | -10... 20<br>15<br>0 | V                  |
| Short-circuit withstand time<br>$V_{DD} = 800\text{V}$ , $V_{DS,peak} < 1200\text{V}$ , $V_{GS,on} = 15\text{V}$ , $T_{j,start} = 25^{\circ}\text{C}$               | $t_{SC}$                                   | 3                    | $\mu\text{s}$      |
| Power dissipation, limited by $T_{vjmax}$<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$                                                              | $P_{tot}$                                  | 228<br>114           | W                  |
| Virtual junction temperature                                                                                                                                        | $T_{vj}$                                   | -55... 175           | $^{\circ}\text{C}$ |
| Storage temperature                                                                                                                                                 | $T_{stg}$                                  | -55... 150           | $^{\circ}\text{C}$ |
| Soldering temperature,<br>wavesoldering only allowed at leads,<br>1.6mm (0.063 in.) from case for 10 s                                                              | $T_{sold}$                                 | 260                  | $^{\circ}\text{C}$ |
| Mounting torque, M3 screw<br>Maximum of mounting processes: 3                                                                                                       | $M$                                        | 0.6                  | Nm                 |

<sup>1</sup> verified by design

<sup>2</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 [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  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified)

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

### 3.2 Dynamic characteristics

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

| Parameter               | Symbol      | Conditions                                                                                 | Value |      |      | Unit          |
|-------------------------|-------------|--------------------------------------------------------------------------------------------|-------|------|------|---------------|
|                         |             |                                                                                            | min.  | typ. | max. |               |
| Input capacitance       | $C_{iss}$   | $V_{DD} = 800\text{V}, V_{GS} = 0\text{V},$<br>$f = 1\text{MHz}, V_{AC} = 25\text{mV}$     | -     | 1900 | -    | pF            |
| Output capacitance      | $C_{oss}$   |                                                                                            | -     | 115  | -    |               |
| Reverse capacitance     | $C_{rss}$   |                                                                                            | -     | 13   | -    |               |
| $C_{oss}$ stored energy | $E_{oss}$   |                                                                                            | -     | 44   | -    | $\mu\text{J}$ |
| Total gate charge       | $Q_G$       | $V_{DD} = 800\text{V}, I_D = 20\text{A},$<br>$V_{GS} = 0/15\text{V}, \text{turn-on pulse}$ | -     | 52   | -    | nC            |
| Gate to source charge   | $Q_{GS,pl}$ |                                                                                            | -     | 15   | -    |               |
| Gate to drain charge    | $Q_{GD}$    |                                                                                            | -     | 13   | -    |               |

### 3.3 Switching characteristics

**Table 6 Switching characteristics, Inductive load <sup>4</sup>**

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

**MOSFET Characteristics,  $T_{vj} = 175^{\circ}\text{C}$** 

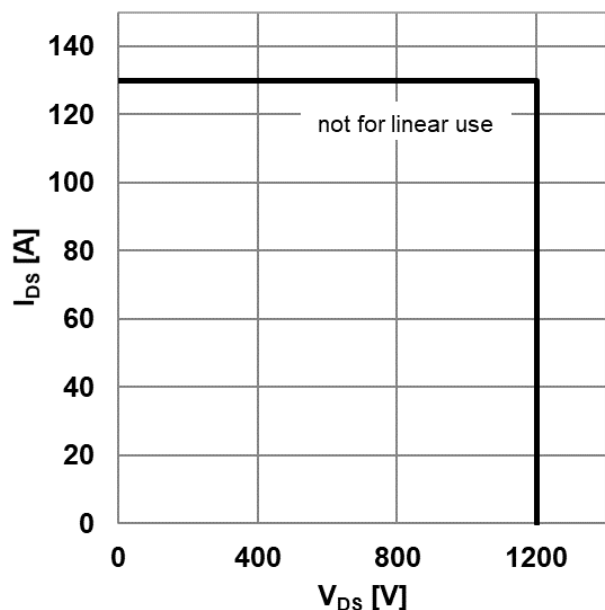
|                        |              |                                                                                                                                                                                                  |   |     |   |               |
|------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|---|---------------|
| Turn-on delay time     | $t_{d(on)}$  | $V_{DD} = 800\text{V}$ , $I_D = 20\text{A}$ ,<br>$V_{GS} = 0/15\text{V}$ , $R_{G,ext} = 2\Omega$ ,<br>$L_{\sigma} = 40\text{nH}$ ,<br>diode:<br>body diode at $V_{GS} = 0\text{V}$<br>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 | - | $\mu\text{J}$ |
| Turn-off energy        | $E_{off}$    |                                                                                                                                                                                                  | - | 75  | - |               |
| Total switching energy | $E_{tot}$    |                                                                                                                                                                                                  | - | 455 | - |               |

**Body Diode Characteristics,  $T_{vj} = 175^{\circ}\text{C}$** 

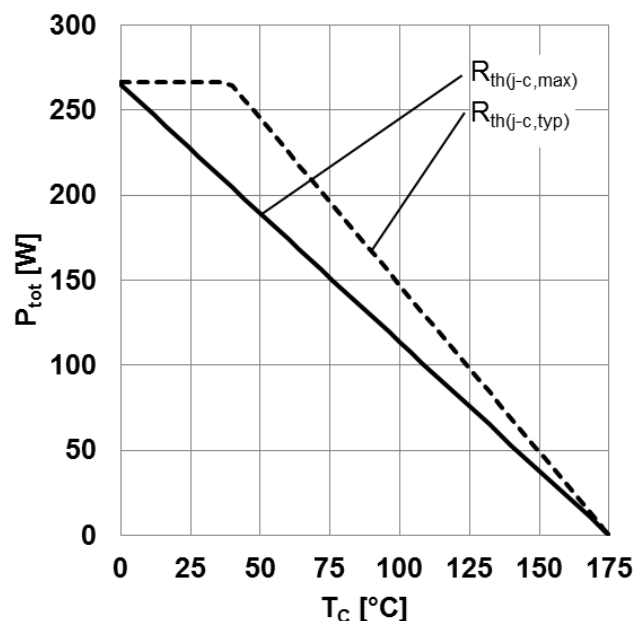
|                                     |           |                                                                                                                                                                                 |   |      |   |               |
|-------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|---|---------------|
| Diode reverse recovery charge       | $Q_{rr}$  | $V_{DD} = 800\text{V}$ , $I_{SD} = 20\text{A}$ ,<br>$V_{GS}$ at diode = $0\text{V}$ ,<br>$di_f/dt = 1000\text{A}/\mu\text{s}$ ,<br>$Q_{rr}$ includes also $Q_C$ ,<br>see Fig. C | - | 0.25 | - | $\mu\text{C}$ |
| Diode peak reverse recovery current | $I_{rrm}$ |                                                                                                                                                                                 | - | 10   | - | A             |

<sup>4</sup> The chip technology was characterized up to  $200\text{ kV}/\mu\text{s}$ . The measured  $dV/dt$  was limited by measurement test setup and package.

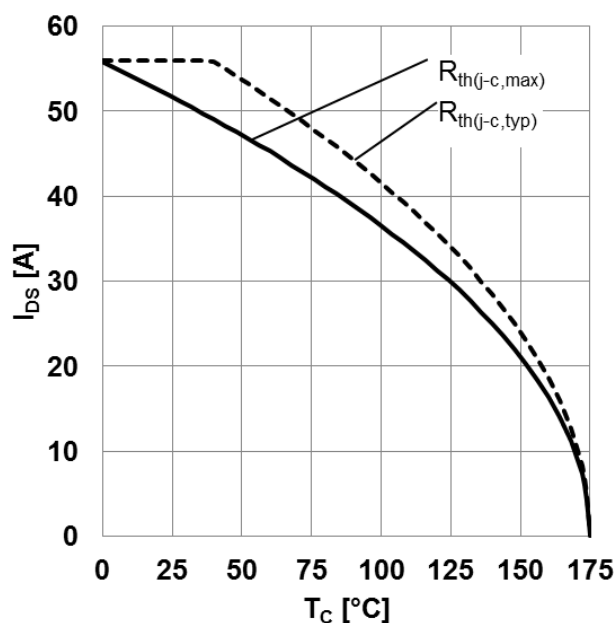
## 4 Electrical characteristic diagrams



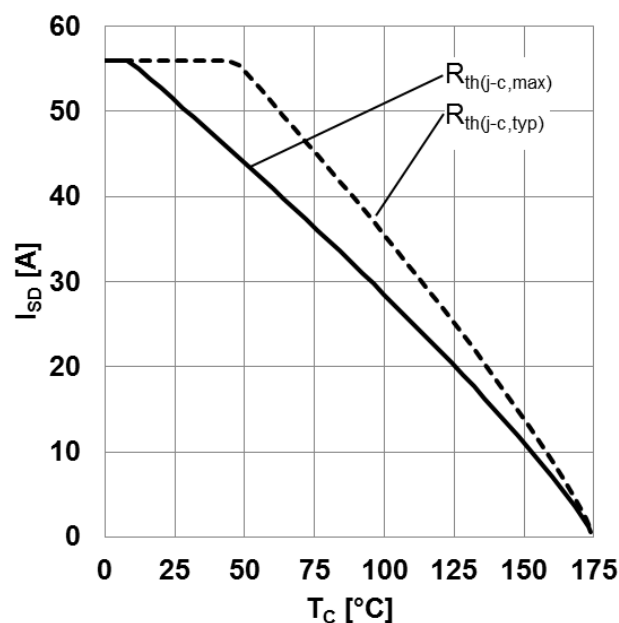
**Figure 1** Reverse bias safe operating area (RBSOA) ( $V_{GS} = 0/15V$ ,  $T_C = 25^\circ C$ ,  $T_J < 175^\circ C$ )



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

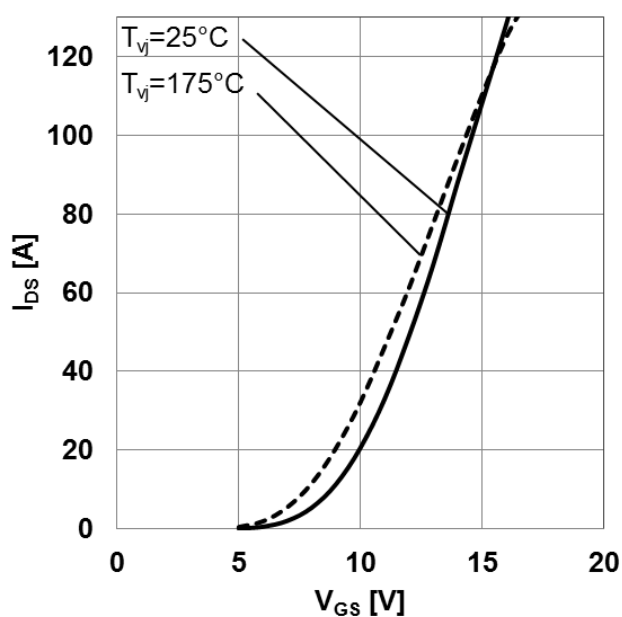


**Figure 3** Maximum DC drain to source current as a function of case temperature limited by bond wire ( $I_{DS} = f(T_C)$ )

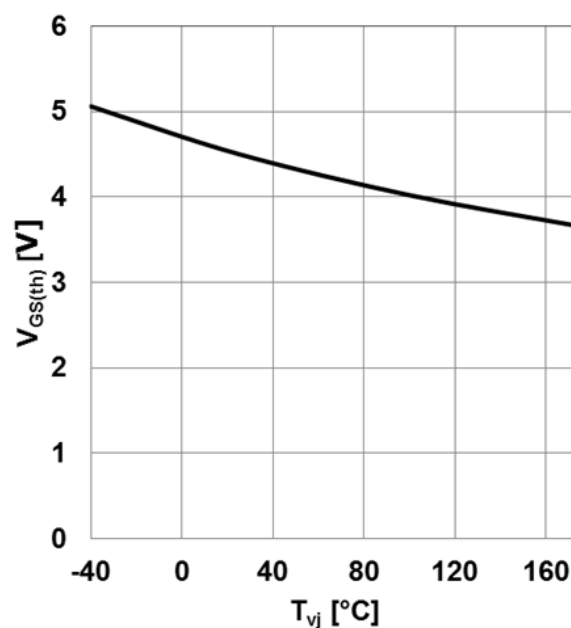


**Figure 4** Maximum source to drain current as a function of case temperature limited by bond wire ( $I_{SD} = f(T_C)$ ,  $V_{GS} = 0V$ )

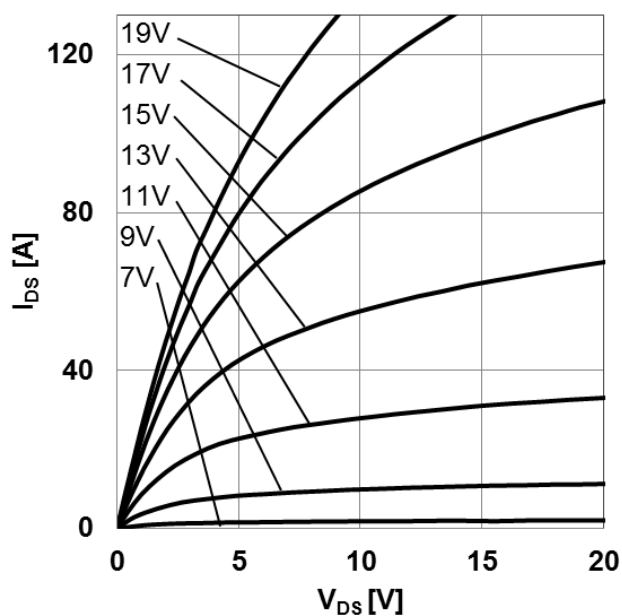




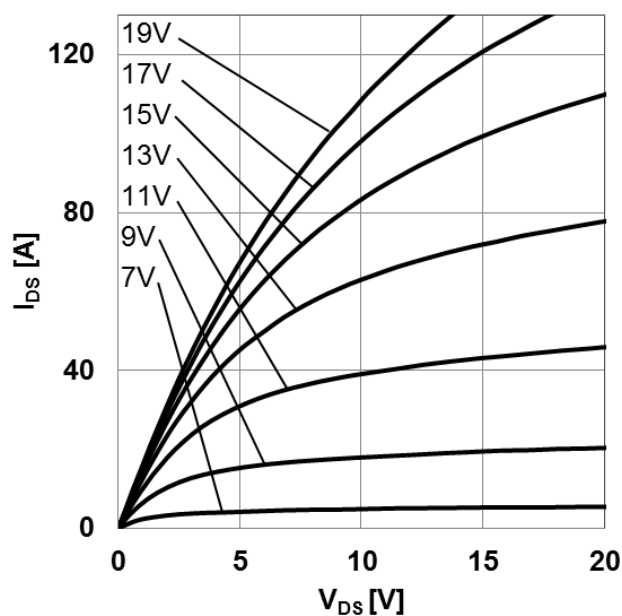
**Figure 5** Typical transfer characteristic  
( $I_{DS} = f(V_{GS})$ ,  $V_{DS} = 20V$ ,  $t_P = 20\mu s$ )



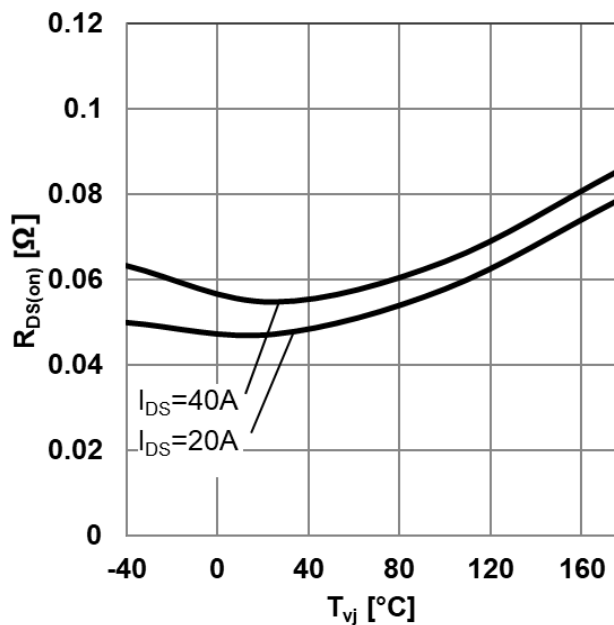
**Figure 6** Typical gate-source threshold voltage as a function of junction temperature  
( $V_{GS(th)} = f(T_{vj})$ ,  $I_{DS} = 10mA$ ,  $V_{GS} = V_{DS}$ )



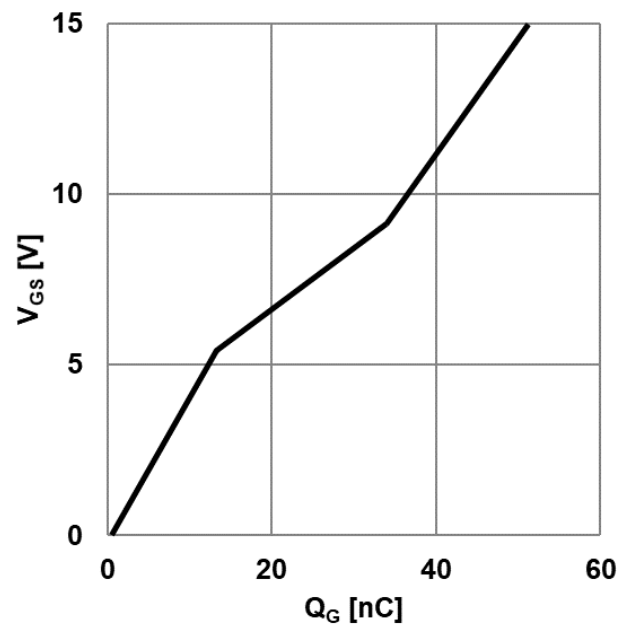
**Figure 7** Typical output characteristic,  $V_{GS}$  as parameter  
( $I_{DS} = f(V_{DS})$ ,  $T_{vj} = 25^\circ C$ ,  $t_P = 20\mu s$ )



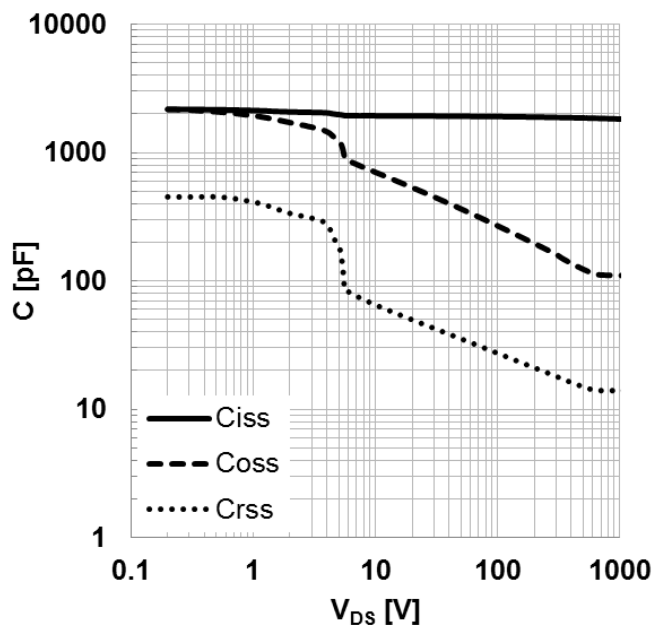
**Figure 8** Typical output characteristic,  $V_{GS}$  as parameter  
( $I_{DS} = f(V_{DS})$ ,  $T_{vj} = 175^\circ C$ ,  $t_P = 20\mu s$ )



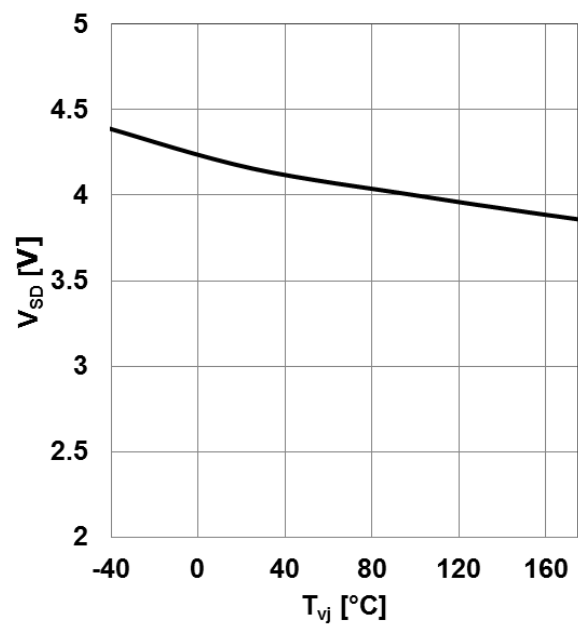
**Figure 9** Typical on-resistance as a function of junction temperature  
 $(R_{DS(on)} = f(T_{vj}), V_{GS}=15V)$



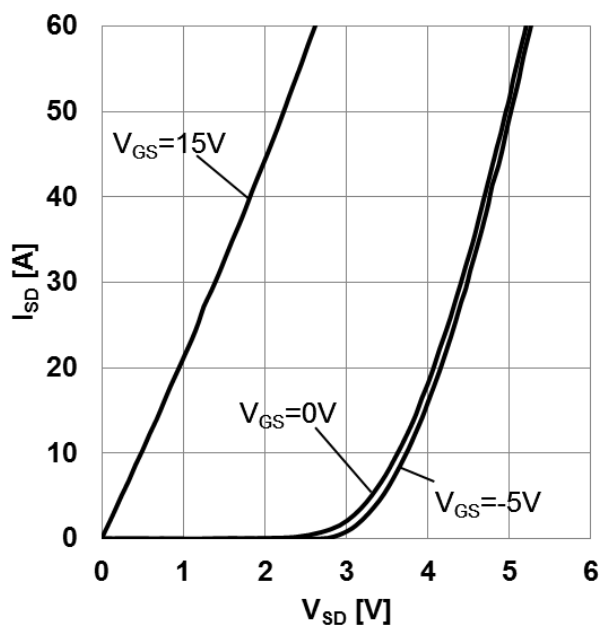
**Figure 10** Typical gate charge ( $V_{GS} = f(Q_G)$ ,  $I_{DS} = 20A$ ,  $V_{DS} = 800V$ , turn-on pulse)



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

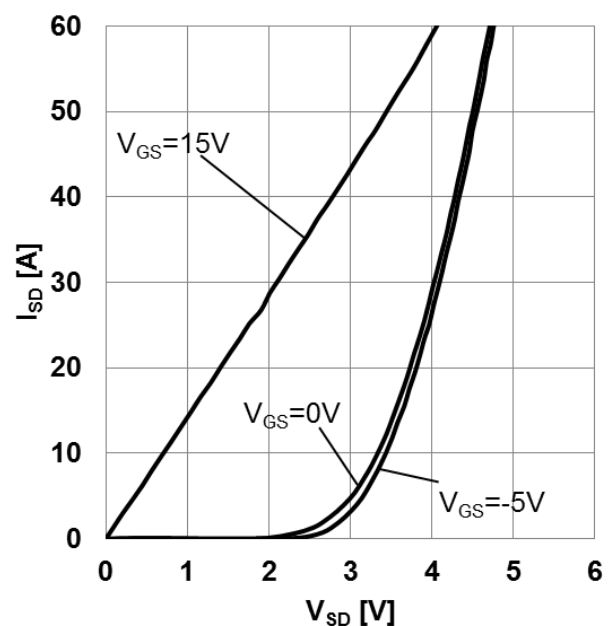


**Figure 12** Typical body diode forward voltage as function of junction temperature  
 $(V_{SD} = f(T_{vj}), V_{GS} = 0V, I_{SD} = 20A)$



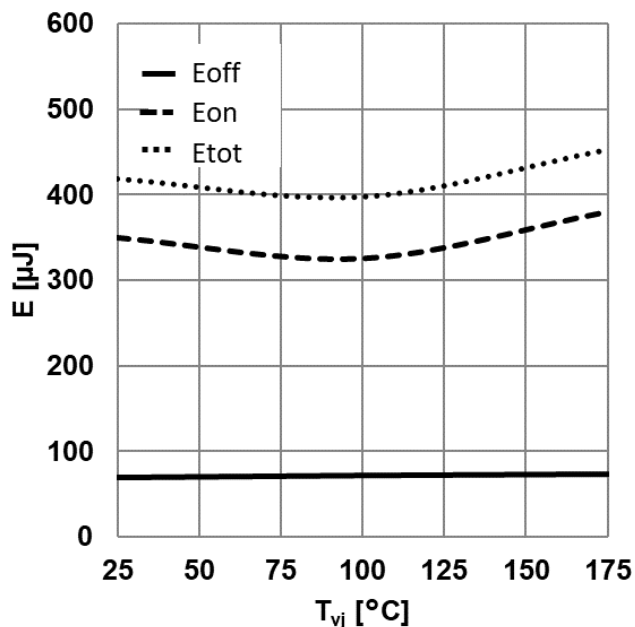
**Figure 13** Typical body diode forward current as function of forward voltage,  $V_{GS}$  as parameter

( $I_{SD} = f(V_{SD})$ ,  $T_{vj} = 25^{\circ}\text{C}$ ,  $t_P = 20\mu\text{s}$ )



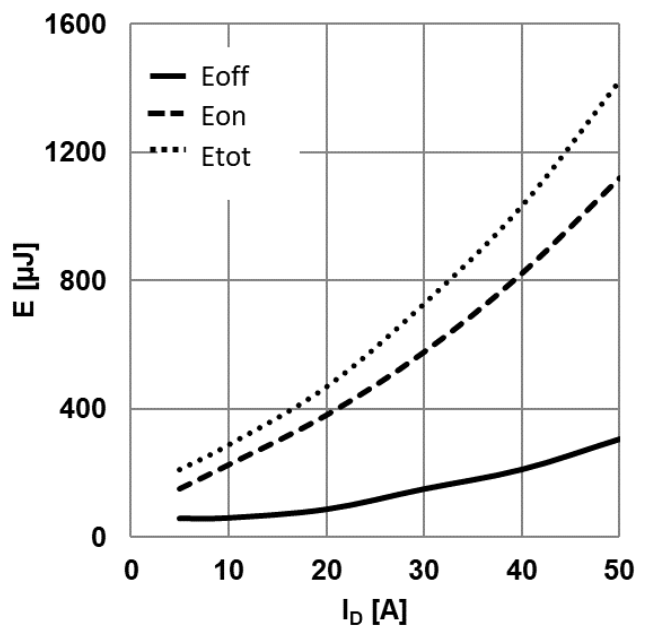
**Figure 14** Typical body diode forward current as function of forward voltage,  $V_{GS}$  as parameter

( $I_{SD} = f(V_{SD})$ ,  $T_{vj} = 175^{\circ}\text{C}$ ,  $t_P = 20\mu\text{s}$ )



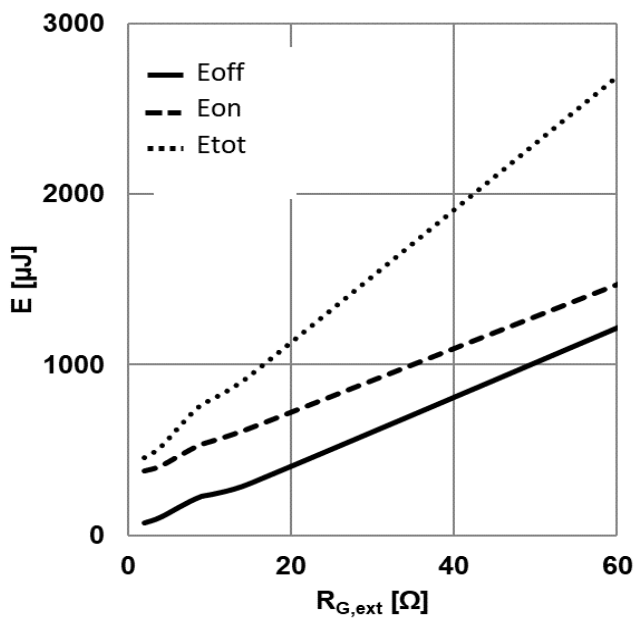
**Figure 15** Typical switching energy losses as a function of junction temperature

( $E = f(T_{vj})$ ,  $V_{DD} = 800\text{V}$ ,  $V_{GS} = 0\text{V}/15\text{V}$ ,  $R_{G,ext} = 2\Omega$ ,  $I_D = 20\text{A}$ , ind. load, test circuit in Fig. E, diode: body diode)

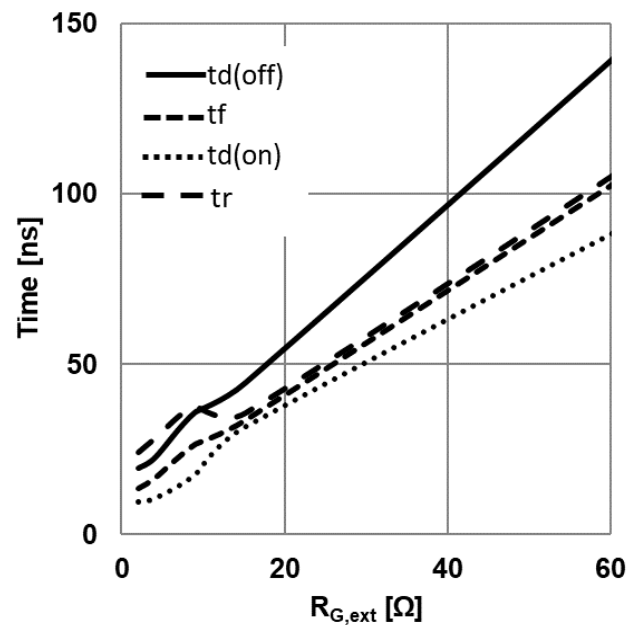


**Figure 16** Typical switching energy losses as a function of drain-source current

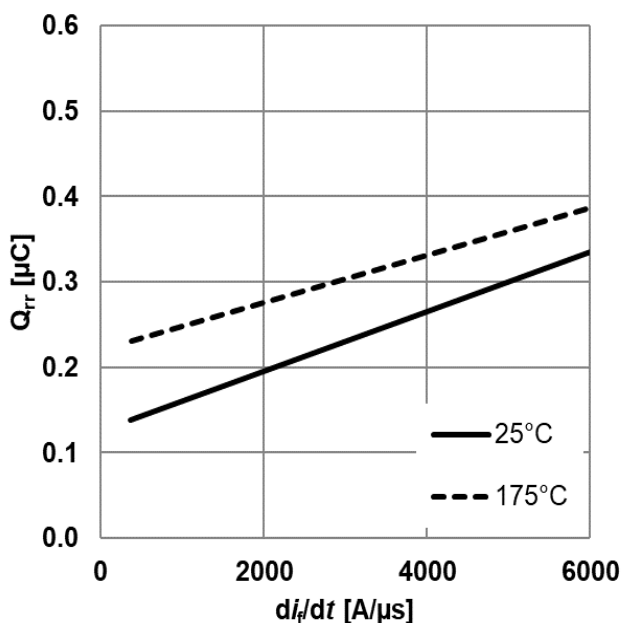
( $E = f(I_{DS})$ ,  $V_{DD} = 800\text{V}$ ,  $V_{GS} = 0\text{V}/15\text{V}$ ,  $R_{G,ext} = 2\Omega$ ,  $T_{vj} = 175^{\circ}\text{C}$ , ind. load, test circuit in Fig. E, diode: body diode)



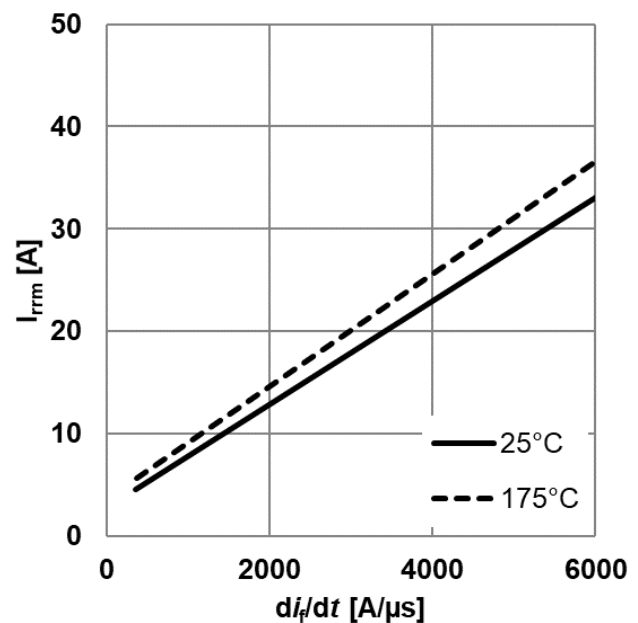
**Figure 17 Typical switching energy losses as a function of gate resistance**  
 $(E = f(R_{G,ext}), V_{DD} = 800V, V_{GS} = 0V/15V, I_D = 20A, T_{vj} = 175^\circ C, \text{ind. load, test circuit in Fig. E, diode: body diode})$



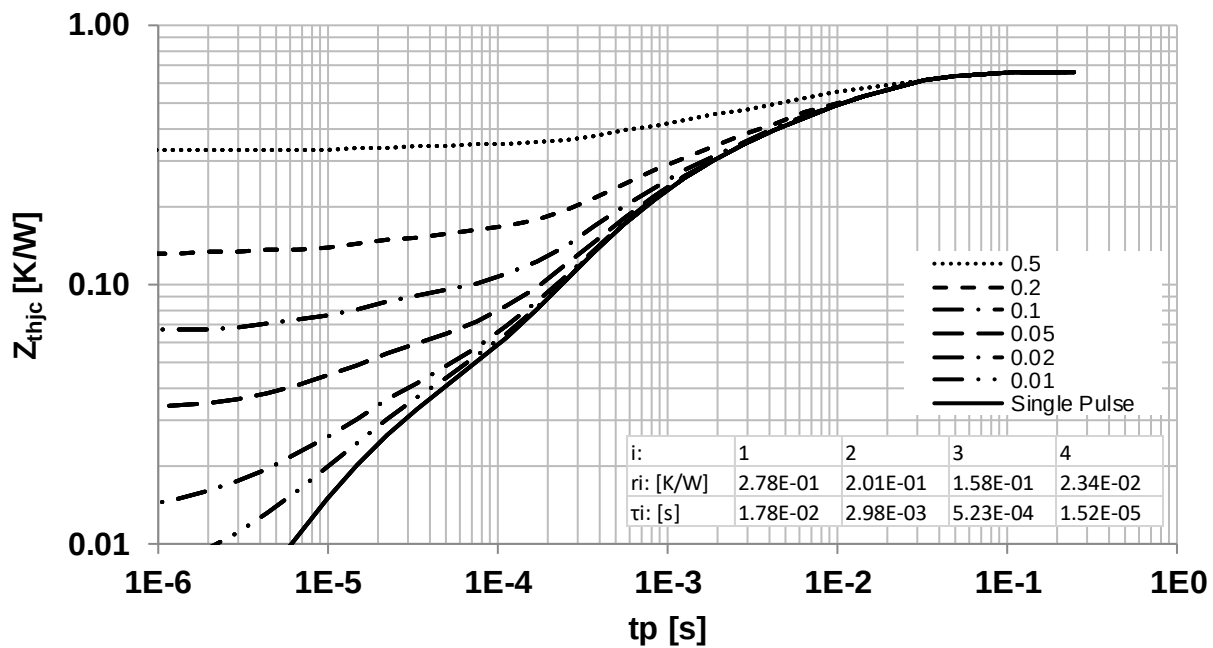
**Figure 18 Typical switching times as a function of gate resistor**  
 $(t = f(R_{G,ext}), V_{DD} = 800V, V_{GS} = 0V/15V, I_D = 20A, T_{vj} = 175^\circ C, \text{ind. load, test circuit in Fig. E, diode: body diode})$



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



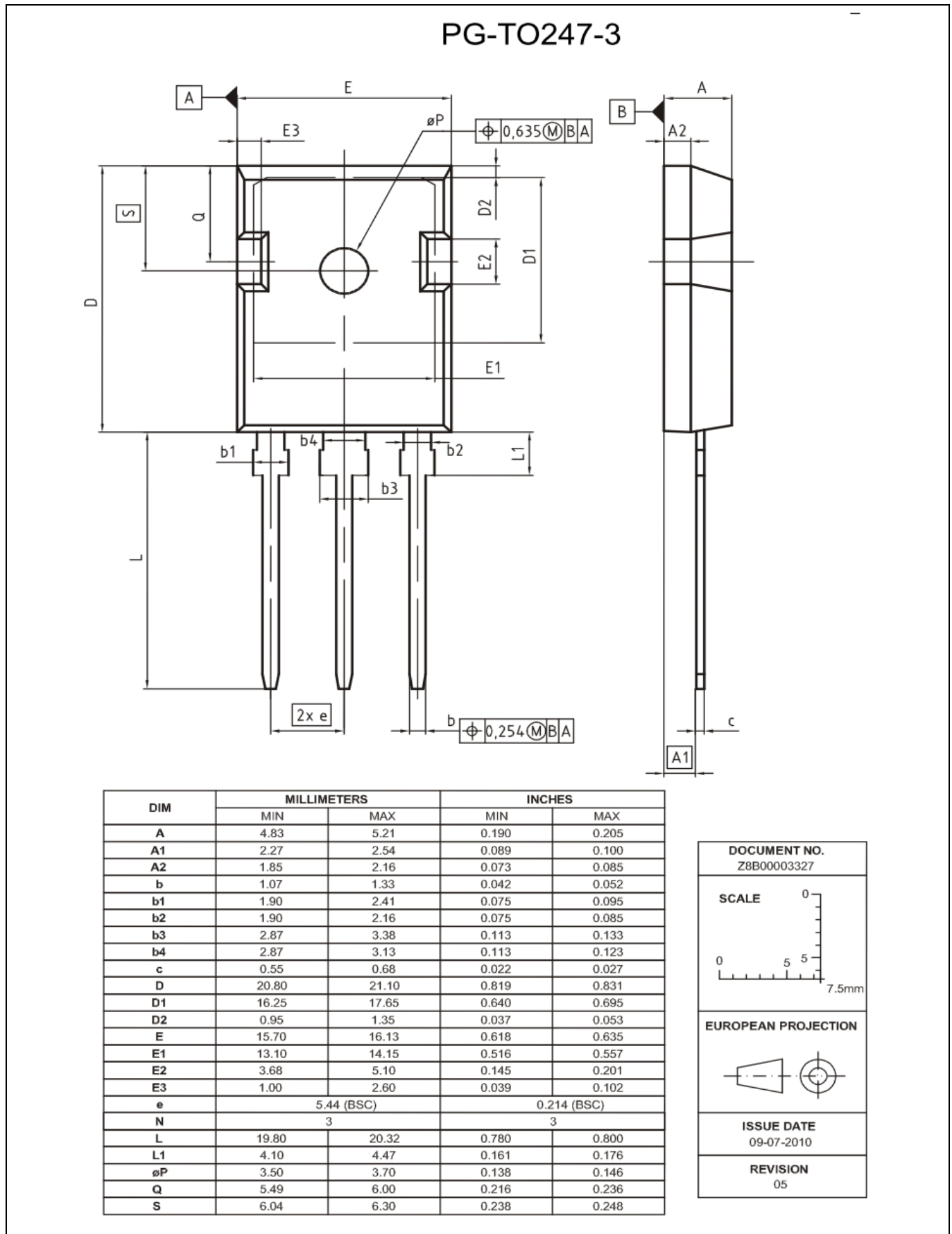
**Figure 20 Typical reverse recovery current as a function of diode current slope**  
 $(I_{rrm} = f(di_t/dt), V_{DD} = 800V, I_D = 20A, \text{ind. load, test circuit in Fig. E})$



**Figure 21 Max. transient thermal resistance (MOSFET/diode)**

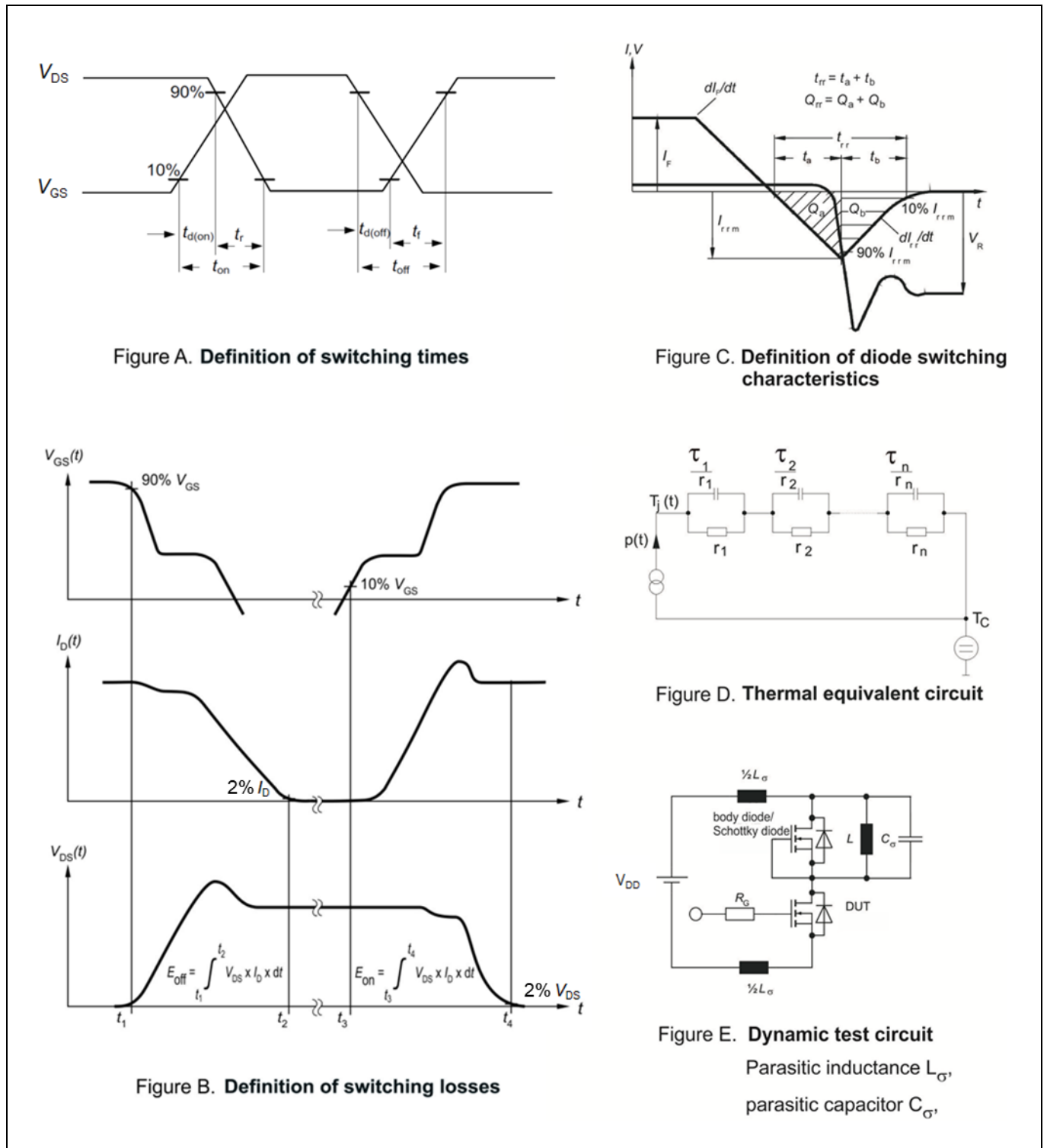
( $Z_{th(j-c,max)} = f(t_p)$ , parameter  $D = t_p/T$ , thermal equivalent circuit in Fig. D)

## 5 Package drawing



**Figure 22 Package drawing**

## 6 Test conditions



**Figure 23 Test conditions**

**Revision history**

**Revision history**

**Major changes since the last revision**

| <b>Document version</b> | <b>Date of release</b> | <b>Description of changes</b>                                                                                                                                                      |
|-------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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                                                      |
| 2.4                     | 2019-12-10             | Move the short circuit time from dynamic characteristics table 5 to maximum ratings table 2.<br>Update the Figure 21 Zth curve.                                                    |
| 2.5                     | 2020-06-12             | Correction of marking letters in table 1                                                                                                                                           |
| 2.6                     | 2020-12-11             | Correction of circuit symbol on page 1                                                                                                                                             |



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