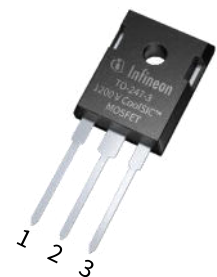
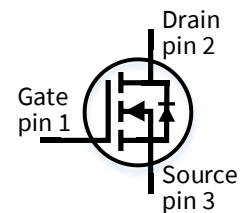


# IMW120R220M1H

## 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 for easy and simple gate drive
- Fully controllable  $dV/dt$
- Robust body diode for hard commutation
- 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          | $V_{DS}$ | $I_D$                               | $R_{DS(on)}$                                  | $T_{vj,max}$ | Marking  | Package    |
|---------------|----------|-------------------------------------|-----------------------------------------------|--------------|----------|------------|
|               |          | $T_C = 25^\circ C, R_{th(j-c,max)}$ | $T_{vj} = 25^\circ C, I_D = 4A, V_{GS} = 18V$ |              |          |            |
| IMW120R220M1H | 1200V    | 13A                                 | 220mΩ                                         | 175°C        | 12M1H220 | 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 $T_{vjmax}$ , $V_{GS} = 18\text{V}$ ,<br>$T_C = 25^{\circ}\text{C}$<br>$T_C = 100^{\circ}\text{C}$              | $I_D$                                   | 13<br>9.5                 | A                  |
| Pulsed drain current, $t_p$ limited by $T_{vjmax}$ , $V_{GS} = 18\text{V}$                                                                                          | $I_{D,pulse}^1$                         | 21                        | 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>$T_C = 100^{\circ}\text{C}$ | $I_{SD}$                                | 13<br>9.3                 | A                  |
| Pulsed body diode current, $t_p$ limited by $T_{vjmax}$                                                                                                             | $I_{SD,pulse}^1$                        | 32                        | 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                 | $V_{GS}$<br>$V_{GS,on}$<br>$V_{GS,off}$ | -7... 23<br>15... 18<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>$T_C = 100^{\circ}\text{C}$                                                              | $P_{tot}$                               | 75<br>37.5                | W                  |
| Virtual junction temperature                                                                                                                                        | $T_{vj}$                                | -55... 175                | $^{\circ}\text{C}$ |
| Storage temperature                                                                                                                                                 | $T_{stg}$                               | -55... 150                | $^{\circ}\text{C}$ |
| Soldering temperature,<br>wave soldering 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 | $R_{th(j-c)}$ |            | -     | 1.5  | 2    | 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 | $R_{DS(on)}$ | $V_{GS} = 18\text{V}, I_D = 4\text{A},$<br>$T_{vj} = 25^{\circ}\text{C}$                                                         | -     | 220  | 294  | mΩ   |
|                                  |              | $T_{vj} = 100^{\circ}\text{C}$                                                                                                   | -     | 280  | -    |      |
|                                  |              | $T_{vj} = 175^{\circ}\text{C}$                                                                                                   | -     | 416  | -    |      |
|                                  |              | $V_{GS} = 15\text{V}, I_D = 4\text{A},$<br>$T_{vj} = 25^{\circ}\text{C}$                                                         | -     | 280  | 372  |      |
|                                  |              |                                                                                                                                  |       |      |      |      |
| Body diode forward voltage       | $V_{SD}$     | $V_{GS} = 0\text{V}, I_{SD} = 4\text{A}$<br>$T_{vj} = 25^{\circ}\text{C}$                                                        | -     | 4.1  | 5.2  | V    |
|                                  |              | $T_{vj} = 100^{\circ}\text{C}$                                                                                                   | -     | 4.0  | -    |      |
|                                  |              | $T_{vj} = 175^{\circ}\text{C}$                                                                                                   | -     | 3.9  | -    |      |
|                                  |              |                                                                                                                                  |       |      |      |      |
| Gate-source threshold voltage    | $V_{GS(th)}$ | (tested after 1 ms pulse at<br>$V_{GS} = 20\text{V}$ )<br>$I_D = 1.6\text{mA}, V_{DS} = V_{GS}$<br>$T_{vj} = 25^{\circ}\text{C}$ | 3.5   | 4.5  | 5.7  | V    |
|                                  |              | $T_{vj} = 175^{\circ}\text{C}$                                                                                                   | -     | 3.6  | -    |      |
|                                  |              |                                                                                                                                  |       |      |      |      |
| Zero gate voltage drain current  | $I_{DSS}$    | $V_{GS} = 0\text{V}, V_{DS} = 1200\text{V}$<br>$T_{vj} = 25^{\circ}\text{C}$                                                     | -     | 0.2  | 95   | μA   |
|                                  |              | $T_{vj} = 175^{\circ}\text{C}$                                                                                                   | -     | 0.6  | -    |      |
|                                  |              |                                                                                                                                  |       |      |      |      |
| Gate-source leakage current      | $I_{GSS}$    | $V_{GS} = 23\text{V}, V_{DS} = 0\text{V}$                                                                                        | -     | -    | 100  | nA   |
|                                  |              | $V_{GS} = -7\text{V}, V_{DS} = 0\text{V}$                                                                                        | -     | -    | -100 | nA   |
| Transconductance                 | $g_{fs}$     | $V_{DS} = 20\text{V}, I_D = 4\text{A}$                                                                                           | -     | 2    | -    | S    |
| Internal gate resistance         | $R_{G,int}$  | $f = 1\text{MHz}, V_{AC} = 25\text{mV}$                                                                                          | -     | 22   | -    | Ω    |

### 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>$f = 1\text{MHz}$ , $V_{AC} = 25\text{mV}$ | -     | 289  | -    | pF            |
| Output capacitance      | $C_{oss}$   |                                                                                               | -     | 16   | -    |               |
| Reverse capacitance     | $C_{rss}$   |                                                                                               | -     | 2    | -    |               |
| $C_{oss}$ stored energy | $E_{oss}$   |                                                                                               | -     | 6    | -    | $\mu\text{J}$ |
| Total gate charge       | $Q_G$       | $V_{DD} = 800\text{V}$ , $I_D = 4\text{A}$ ,<br>$V_{GS} = 0/18\text{V}$ , turn-on pulse       | -     | 8.5  | -    | nC            |
| Gate to source charge   | $Q_{GS,pl}$ |                                                                                               | -     | 2.5  | -    |               |
| Gate to drain charge    | $Q_{GD}$    |                                                                                               | -     | 2    | -    |               |

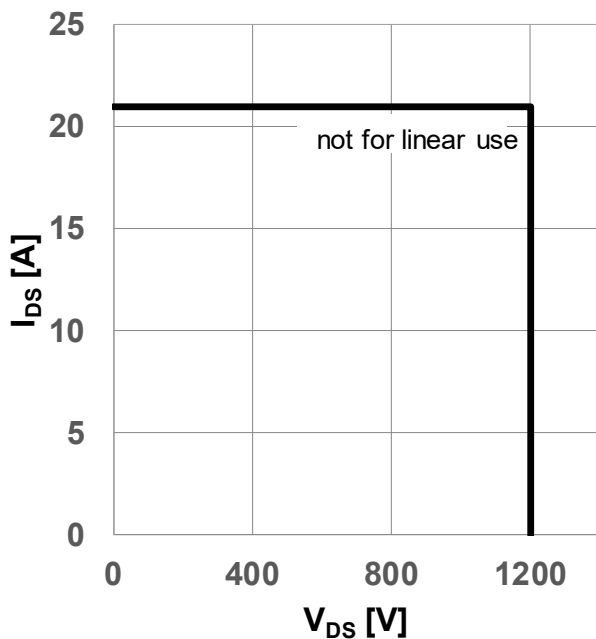
### 3.3 Switching characteristics

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

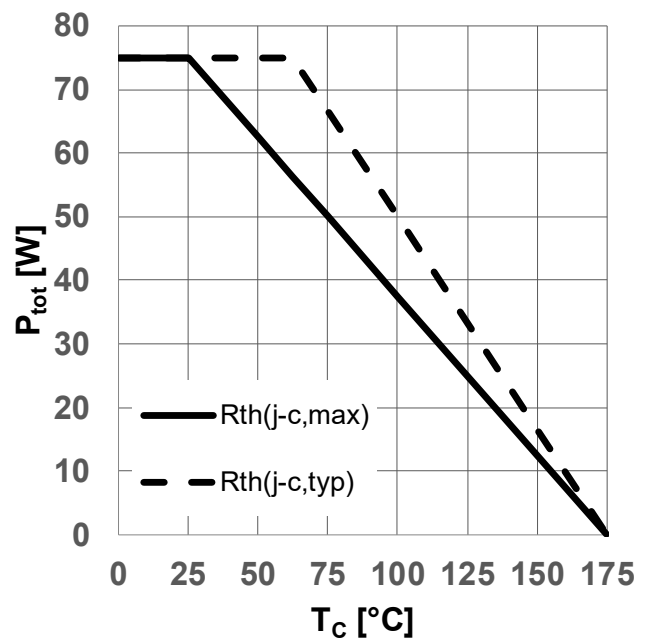
| Parameter                                                  | Symbol              | Conditions                                                                                                                                                                                    | Value |      |      | Unit          |
|------------------------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|---------------|
|                                                            |                     |                                                                                                                                                                                               | min.  | typ. | max. |               |
| MOSFET Characteristics, $T_{vj} = 25^{\circ}\text{C}$      |                     |                                                                                                                                                                                               |       |      |      |               |
| Turn-on delay time                                         | $t_{d(\text{on})}$  | $V_{DD} = 800\text{V}, I_D = 4\text{A},$<br>$V_{GS} = 0/18\text{V}, R_{G,\text{ext}} = 2\Omega,$<br>$L_{\sigma} = 40\text{nH},$<br>diode:<br>body diode at $V_{GS} = 0\text{V}$<br>see Fig. E | -     | 5    | -    | ns            |
| Rise time                                                  | $t_r$               |                                                                                                                                                                                               | -     | 1.4  | -    |               |
| Turn-off delay time                                        | $t_{d(\text{off})}$ |                                                                                                                                                                                               | -     | 10   | -    |               |
| Fall time                                                  | $t_f$               |                                                                                                                                                                                               | -     | 14   | -    |               |
| Turn-on energy                                             | $E_{\text{on}}$     |                                                                                                                                                                                               | -     | 61   | -    | $\mu\text{J}$ |
| Turn-off energy                                            | $E_{\text{off}}$    |                                                                                                                                                                                               | -     | 7    | -    |               |
| Total switching energy                                     | $E_{\text{tot}}$    |                                                                                                                                                                                               | -     | 68   | -    |               |
| Body Diode Characteristics, $T_{vj} = 25^{\circ}\text{C}$  |                     |                                                                                                                                                                                               |       |      |      |               |
| Diode reverse recovery charge                              | $Q_{rr}$            | $V_{DD} = 800\text{V}, I_{SD} = 4\text{A},$<br>$V_{GS}$ at diode = 0V,<br>$di_t/dt = 1000\text{A}/\mu\text{s},$<br>$Q_{rr}$ includes also $Q_C,$<br>see Fig. C                                | -     | 78   | -    | nC            |
| Diode peak reverse recovery current                        | $I_{rrm}$           |                                                                                                                                                                                               | -     | 1.4  | -    | A             |
|                                                            |                     |                                                                                                                                                                                               |       |      |      |               |
| MOSFET Characteristics, $T_{vj} = 175^{\circ}\text{C}$     |                     |                                                                                                                                                                                               |       |      |      |               |
| Turn-on delay time                                         | $t_{d(\text{on})}$  | $V_{DD} = 800\text{V}, I_D = 4\text{A},$<br>$V_{GS} = 0/18\text{V}, R_{G,\text{ext}} = 2\Omega,$<br>$L_{\sigma} = 40\text{nH},$<br>diode:<br>body diode at $V_{GS} = 0\text{V}$<br>see Fig. E | -     | 5    | -    | ns            |
| Rise time                                                  | $t_r$               |                                                                                                                                                                                               | -     | 3.5  | -    |               |
| Turn-off delay time                                        | $t_{d(\text{off})}$ |                                                                                                                                                                                               | -     | 10   | -    |               |
| Fall time                                                  | $t_f$               |                                                                                                                                                                                               | -     | 14   | -    |               |
| Turn-on energy                                             | $E_{\text{on}}$     |                                                                                                                                                                                               | -     | 76   | -    | $\mu\text{J}$ |
| Turn-off energy                                            | $E_{\text{off}}$    |                                                                                                                                                                                               | -     | 7    | -    |               |
| Total switching energy                                     | $E_{\text{tot}}$    |                                                                                                                                                                                               | -     | 83   | -    |               |
| Body Diode Characteristics, $T_{vj} = 175^{\circ}\text{C}$ |                     |                                                                                                                                                                                               |       |      |      |               |
| Diode reverse recovery charge                              | $Q_{rr}$            | $V_{DD} = 800\text{V}, I_{SD} = 4\text{A},$<br>$V_{GS}$ at diode = 0V,<br>$di_t/dt = 1000\text{A}/\mu\text{s},$<br>$Q_{rr}$ includes also $Q_C,$<br>see Fig. C                                | -     | 98   | -    | nC            |
| Diode peak reverse recovery current                        | $I_{rrm}$           |                                                                                                                                                                                               | -     | 2    | -    | A             |

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

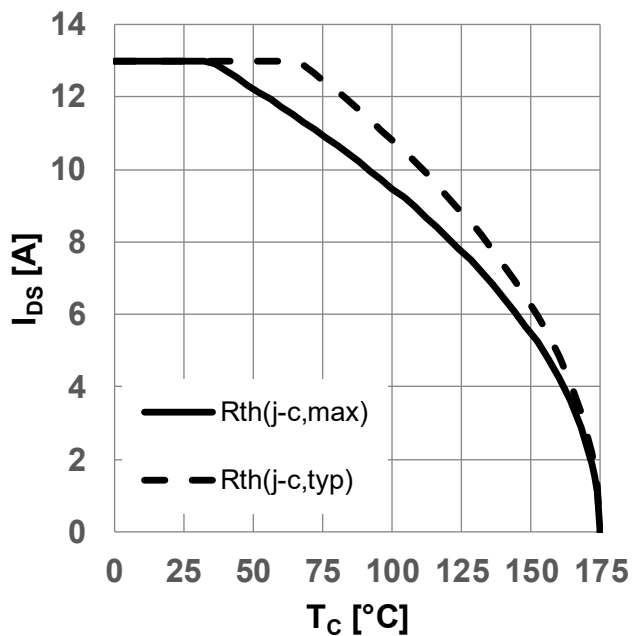
## 4 Electrical characteristic diagrams



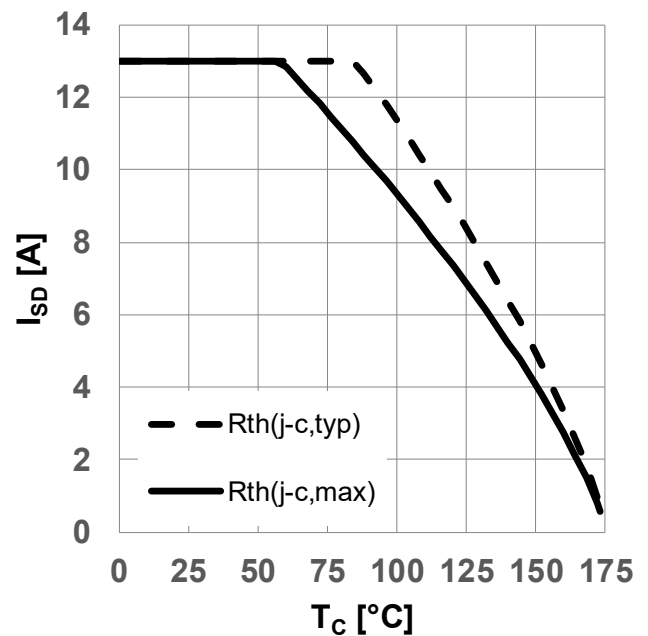
**Figure 1** Safe operating area (SOA)  
( $V_{GS} = 0/18V$ ,  $T_c = 25^\circ C$ ,  $T_j \leq 175^\circ C$ )



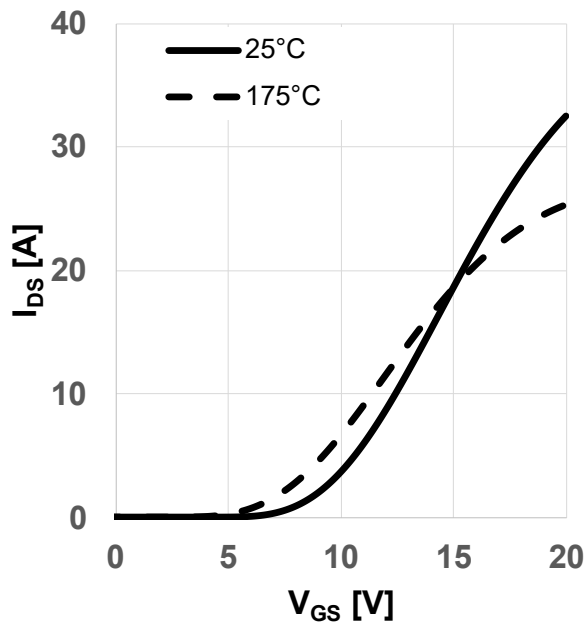
**Figure 2** Power dissipation as a function of case temperature limited by bond wire  
( $P_{tot} = f(T_c)$ )



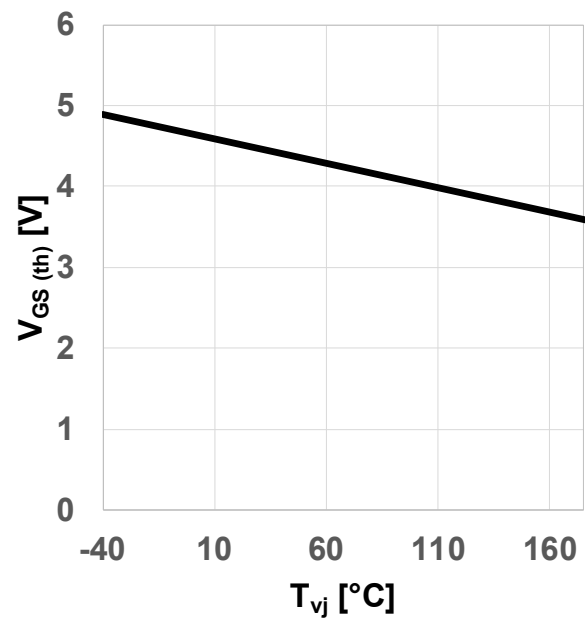
**Figure 3** Maximum DC drain to source current as a function of case temperature limited by bond wire ( $I_{DS} = f(T_c)$ )



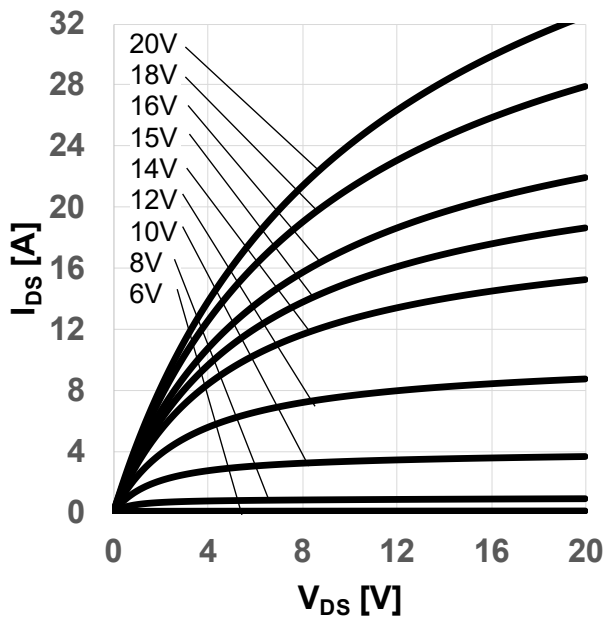
**Figure 4** Maximum source to drain current as a function of case temperature limited by bond wire ( $I_{SD} = f(T_c)$ ,  $V_{GS} = 0V$ )



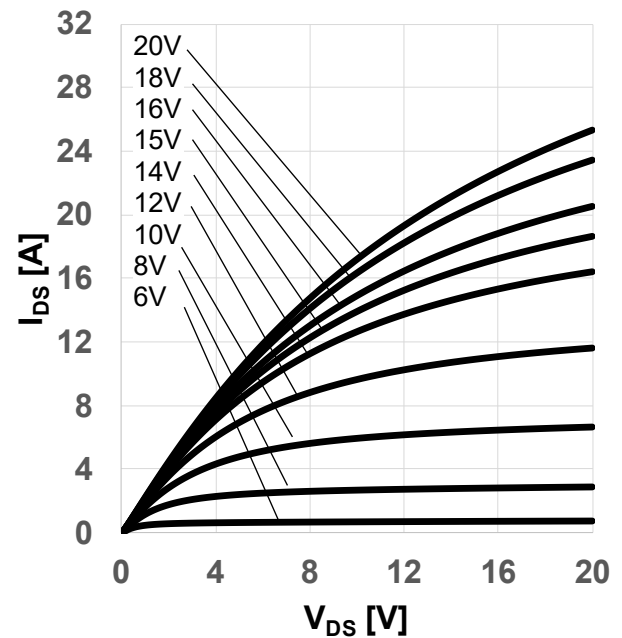
**Figure 5** Typical transfer characteristic  
( $I_{DS} = f(V_{GS})$ ,  $V_{DS} = 20V$ ,  $t_P = 20\mu s$ )



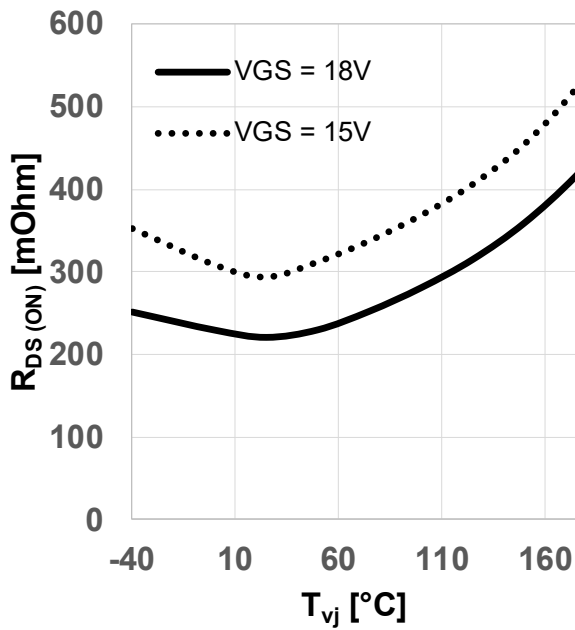
**Figure 6** Typical gate-source threshold voltage  
as a function of junction temperature  
( $V_{GS(th)} = f(T_{vj})$ ,  $I_{DS} = 1.6mA$ ,  $V_{GS} = V_{DS}$ )



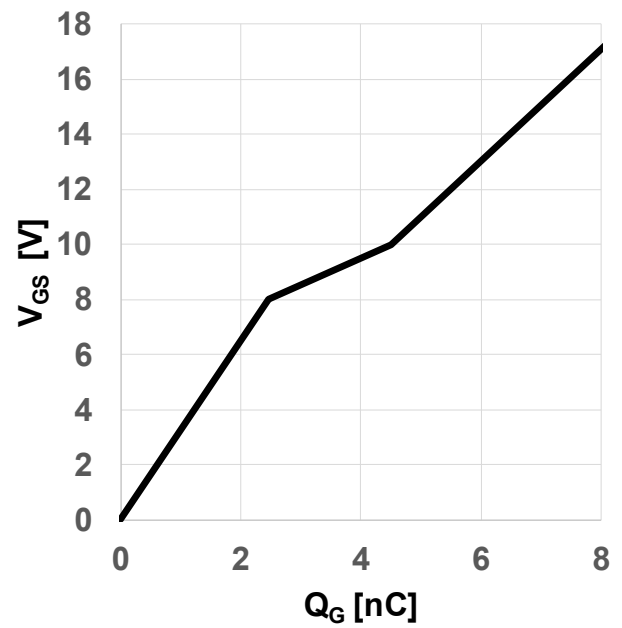
**Figure 7** Typical output characteristic,  $V_{GS}$  as  
parameter  
( $I_{DS} = f(V_{DS})$ ,  $T_{vj} = 25^\circ C$ ,  $t_P = 20\mu s$ )



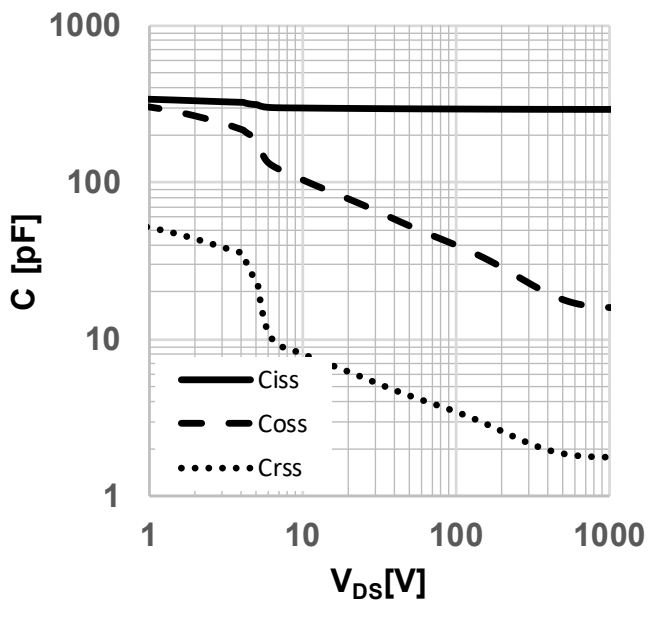
**Figure 8** Typical output characteristic,  $V_{GS}$  as  
parameter  
( $I_{DS} = f(V_{DS})$ ,  $T_{vj} = 175^\circ C$ ,  $t_P = 20\mu s$ )



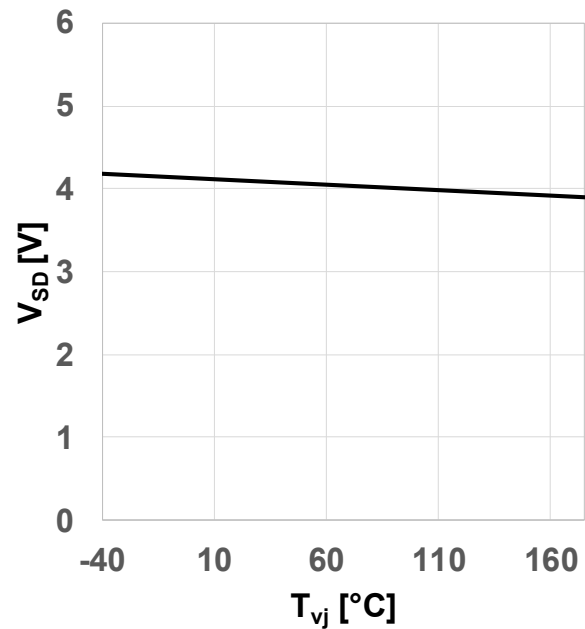
**Figure 9** Typical on-resistance as a function of junction temperature  
 $(R_{DS(on)} = f(T_{vj}), I_{DS} = 4A)$



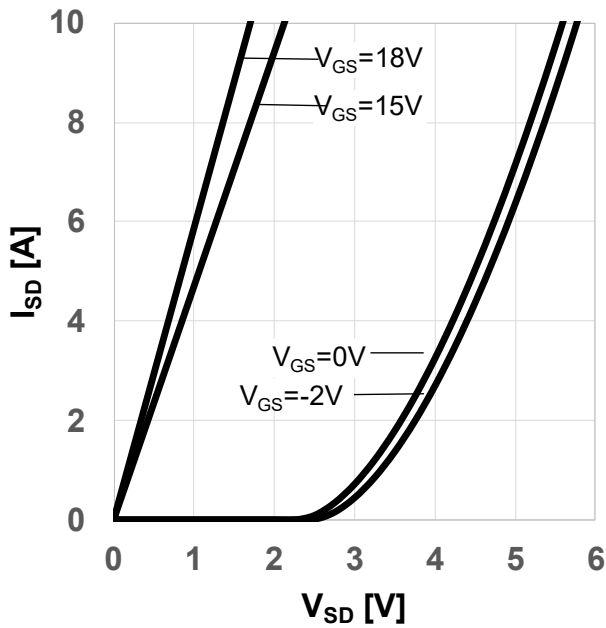
**Figure 10** Typical gate charge  
 $(V_{GS} = f(Q_G), I_{DS} = 4A, V_{DS} = 800V, \text{turn-on pulse})$



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

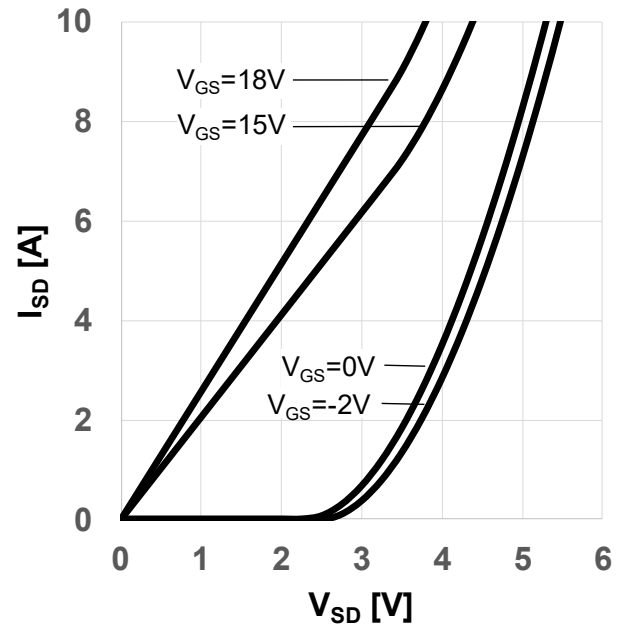


**Figure 12** Typical body diode forward voltage as function of junction temperature  
 $(V_{SD} = f(T_{vj}), V_{GS} = 0V, I_{SD} = 4A)$



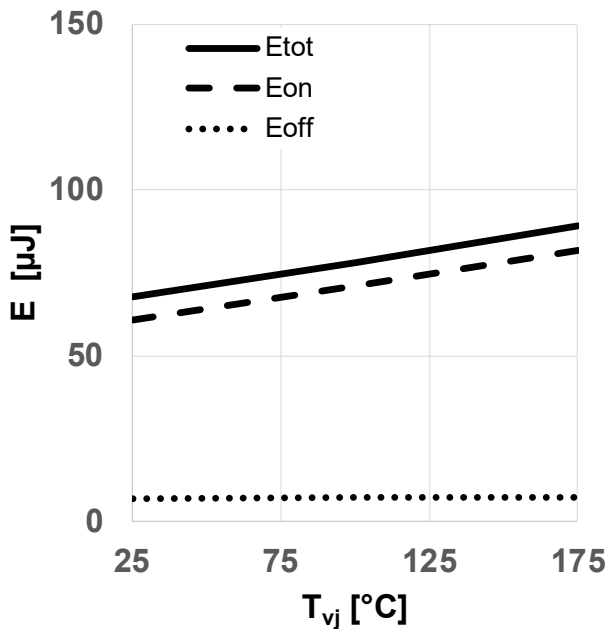
**Figure 13** Typical body diode forward current as function of forward voltage,  $V_{GS}$  as parameter

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

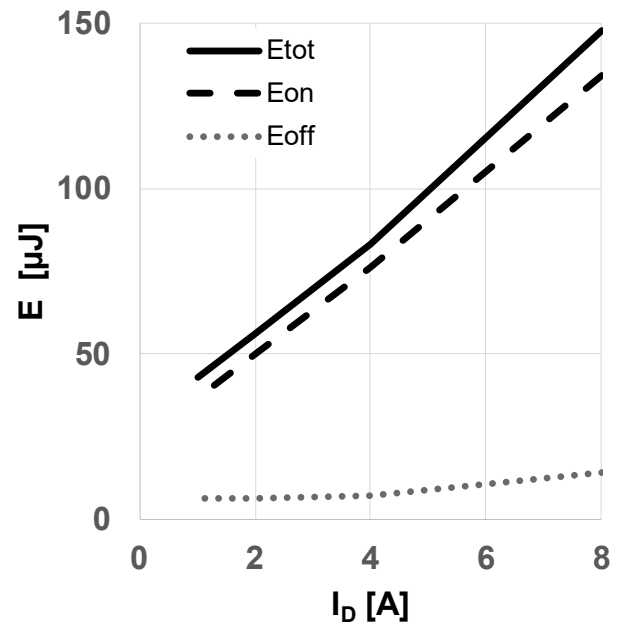


**Figure 14** Typical body diode forward current as function of forward voltage,  $V_{GS}$  as parameter

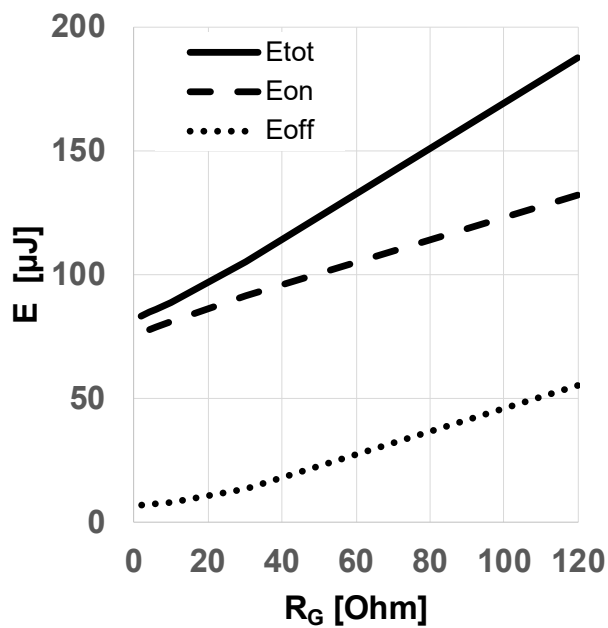
( $I_{SD} = f(V_{SD})$ ,  $T_{vj} = 175^\circ\text{C}$ ,  $t_P = 20\mu\text{s}$ )



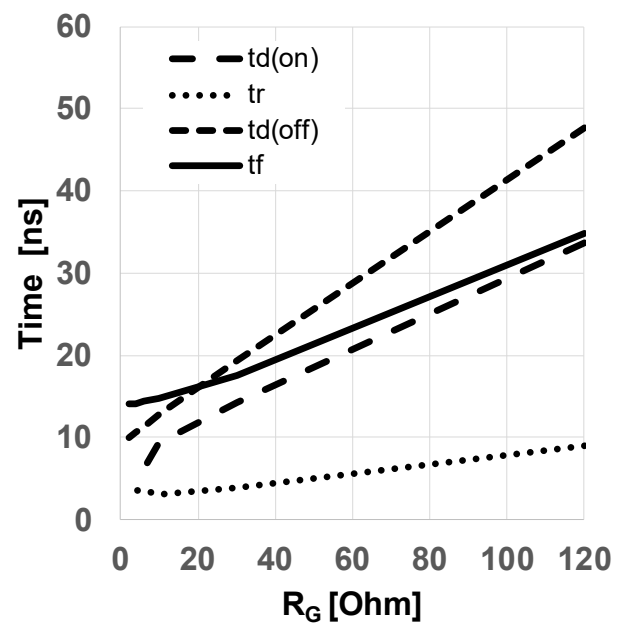
**Figure 15** Typical switching energy losses as a function of junction temperature  
( $E = f(T_{vj})$ ,  $V_{DD} = 800\text{V}$ ,  $V_{GS} = 0\text{V}/18\text{V}$ ,  $R_{G,ext} = 2\Omega$ ,  $I_D = 4\text{A}$ , ind. load, test circuit in Fig. E, diode: body diode at  $V_{GS} = 0\text{V}$ )



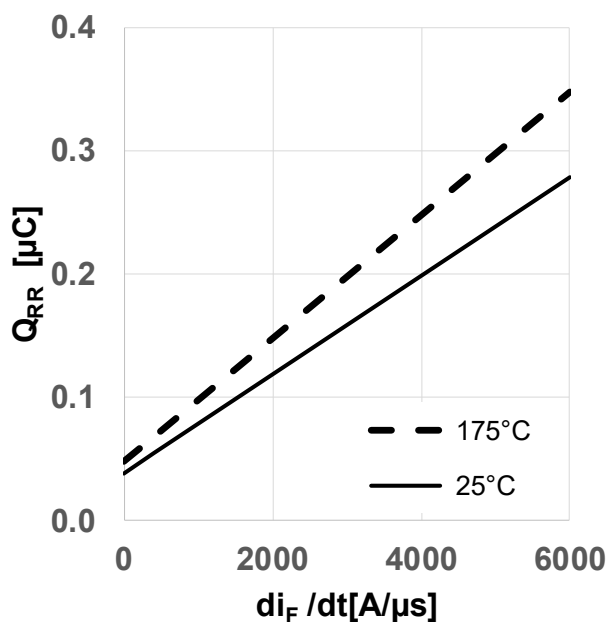
**Figure 16** Typical switching energy losses as a function of drain-source current  
( $E = f(I_{DS})$ ,  $V_{DD} = 800\text{V}$ ,  $V_{GS} = 0\text{V}/18\text{V}$ ,  $R_{G,ext} = 2\Omega$ ,  $T_{vj} = 175^\circ\text{C}$ , ind. load, test circuit in Fig. E, diode: body diode at  $V_{GS} = 0\text{V}$ )



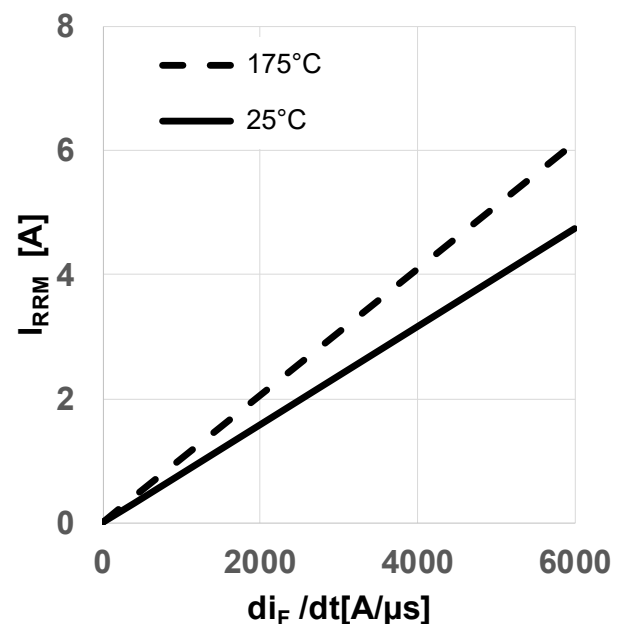
**Figure 17** Typical switching energy losses as a function of gate resistance  
 $(E = f(R_{G,ext}), V_{DD} = 800V, V_{GS} = 0V/18V, I_D = 4A, T_{vj} = 175^\circ C, \text{ind. load, test circuit in Fig. E, diode: body diode at } V_{GS} = 0V)$



**Figure 18** Typical switching times as a function of gate resistor  
 $(t = f(R_{G,ext}), V_{DD} = 800V, V_{GS} = 0V/18V, I_D = 4A, T_{vj} = 175^\circ C, \text{ind. load, test circuit in Fig. E, diode: body diode at } V_{GS} = 0V)$



**Figure 19** Typical reverse recovery charge as a function of diode current slope  
 $(Q_{rr} = f(di_i/dt), V_{DD} = 800V, V_{GS} = 0V/18V, I_D = 4A, \text{ind. load, test circuit in Fig.E, body diode at } V_{GS} = 0V)$

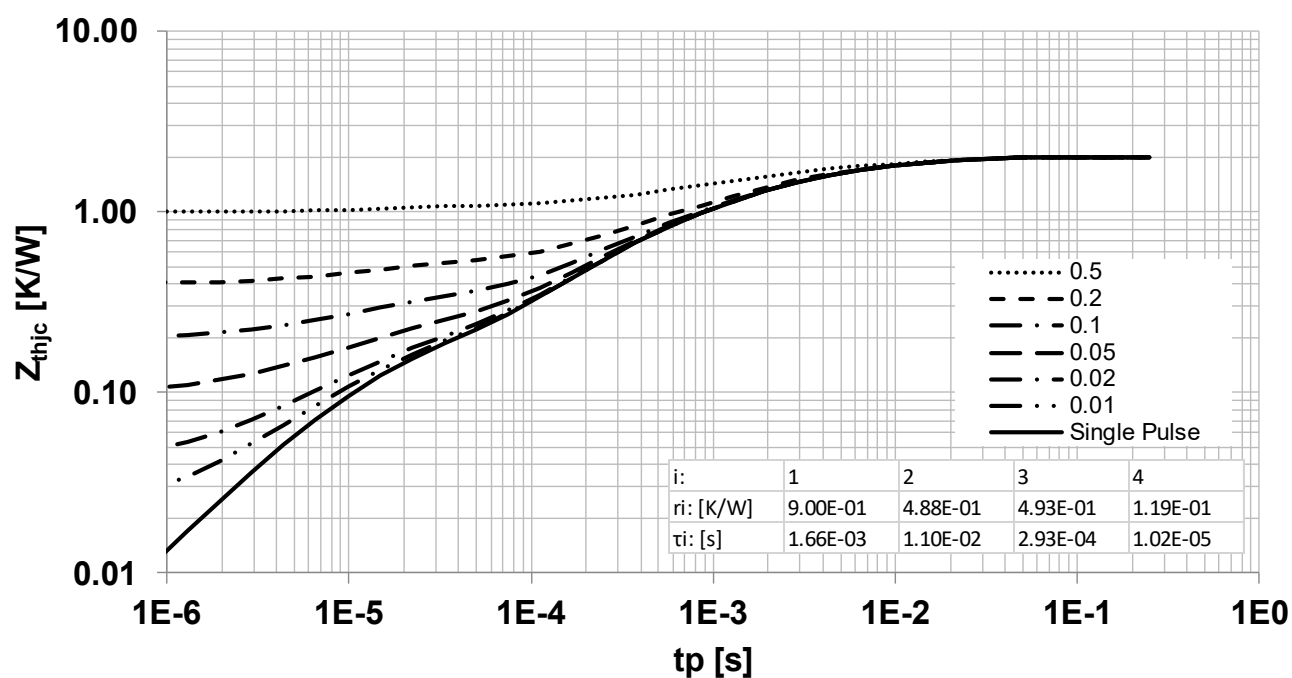


**Figure 20** Typical reverse recovery current as a function of diode current slope  
 $(I_{rrm} = f(di_i/dt), V_{DD} = 800V, V_{GS} = 0V/18V, I_D = 4A, \text{ind. load, test circuit in Fig.E, body diode at } V_{GS} = 0V)$

# IMW120R220M1H

## CoolSiC™ 1200V SiC Trench MOSFET

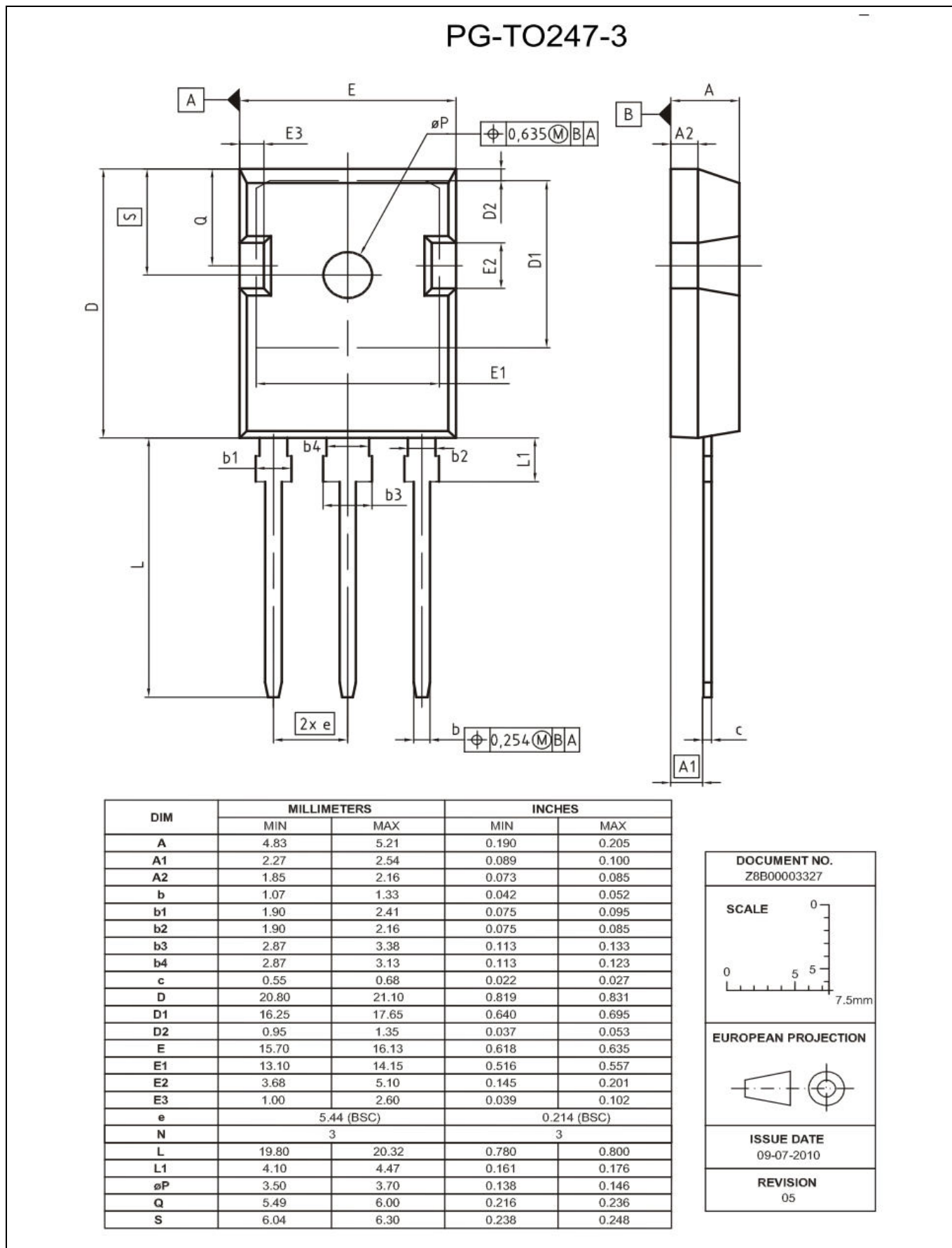
### Electrical characteristic diagrams



**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**

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### Test conditions

## 6 Test conditions

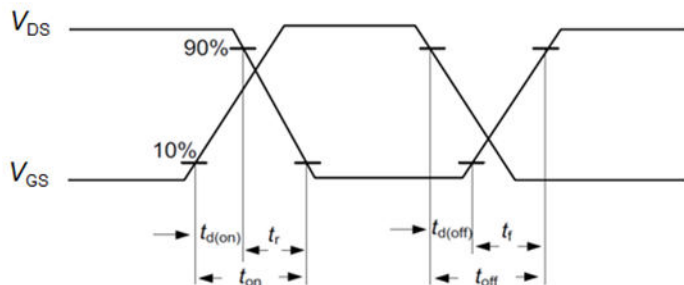


Figure A. Definition of switching times

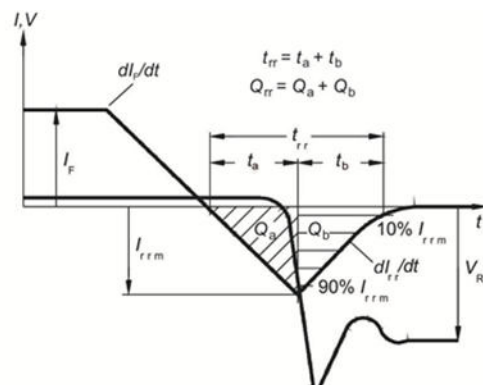


Figure C. Definition of diode switching characteristics

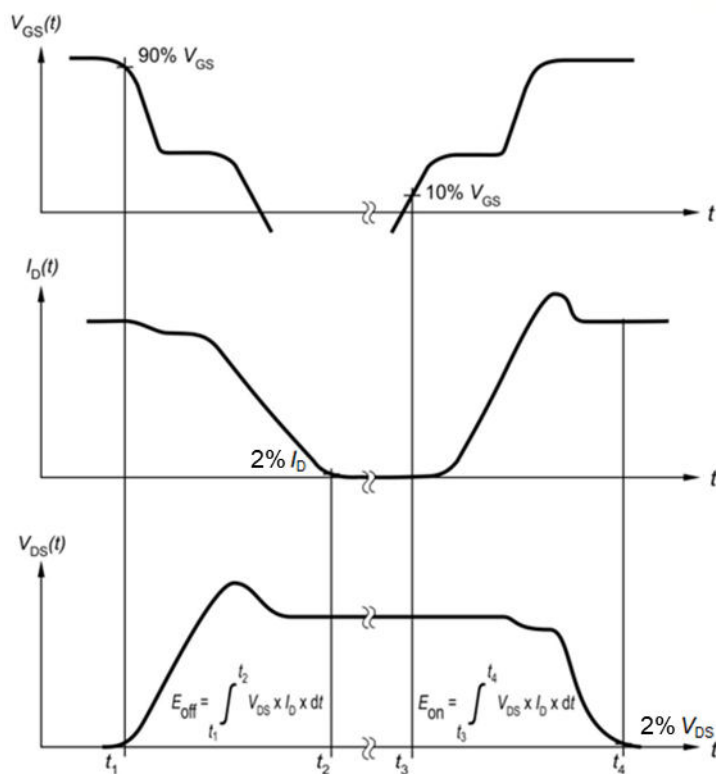


Figure B. Definition of switching losses

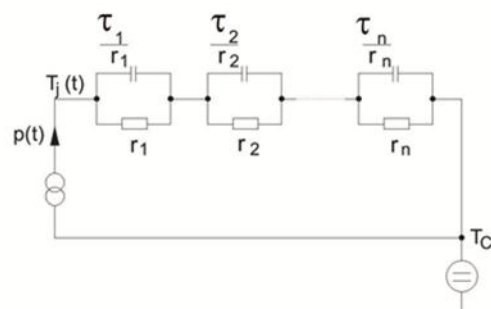


Figure D. Thermal equivalent circuit

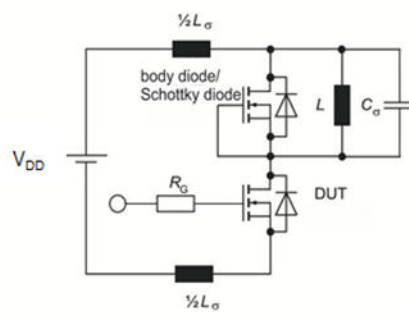


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,

Figure 23 Test conditions

**Revision history**

**Revision history**

| <b>Document version</b> | <b>Date of release</b> | <b>Description of changes</b>                                                                                                                                                                                         |
|-------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2.0                     | 2019-08-22             | Final Datasheet                                                                                                                                                                                                       |
| 2.1                     | 2019-12-10             | <ul style="list-style-type: none"><li>• Move the short circuit time from dynamic characteristics table 5 to maximum ratings table 2.</li><li>• Update the Figure 12, 13, 14 the body diode forward voltage.</li></ul> |
| 2.2                     | 2020-12-11             | Correction of circuit symbol on page 1                                                                                                                                                                                |

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