

## SiC MOSFET

### CoolSiC™ MOSFET 650 V G2

Built on Infineon's robust 2<sup>nd</sup> generation Silicon Carbide trench technology, the 650 V CoolSiC™ MOSFET delivers unparalleled performance, superior reliability, and great ease of use. It enables cost effective, highly efficient, and simplified designs to fulfill the ever-growing system and market needs.

### Features

- Ultra-low switching losses
- Benchmark gate threshold voltage,  $V_{GS(th)} = 4.5\text{ V}$
- Robust against parasitic turn-on even with 0 V turn-off gate voltage
- Flexible driving voltage and compatible with bipolar driving scheme
- Robust body diode operation under hard commutation events
- .XT interconnection technology for best-in-class thermal performance

### Benefits

- Enables high efficiency and high power density designs
- Facilitates great ease of use and integration
- Provides the best price performance ratio compared to Industry's most ambitious roadmaps
- Reduces the size, weight and bill of materials of the systems
- Enhances system robustness and reliability

### Potential applications

- SMPS
- Solar PV inverters
- Energy storage and battery formation
- UPS
- EV charging infrastructure
- Motor drives

### Product validation

Fully qualified according to JEDEC for Industrial Applications

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

**Table 1** Key performance parameters

| Parameter                         | Value | Unit |
|-----------------------------------|-------|------|
| $V_{DSS}$ over full $T_{j,range}$ | 650   | V    |
| $R_{DS(on),typ}$                  | 10.0  | mΩ   |
| $R_{DS(on),max}$                  | 13.1  | mΩ   |
| $Q_{G,typ}$                       | 113   | nC   |
| $I_{D,pulse}$                     | 567   | A    |
| $Q_{oss} @ 400\text{ V}$          | 212   | nC   |
| $E_{oss} @ 400\text{ V}$          | 28.8  | μJ   |

| Part number   | Package     | Marking  | Related links  |
|---------------|-------------|----------|----------------|
| IMDQ65R010M2H | PG-HDSOP-22 | 65R010M2 | see Appendix A |

Q-DPAK

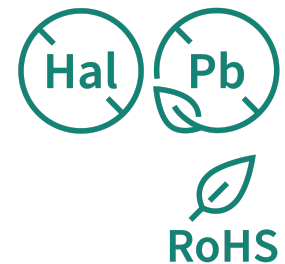
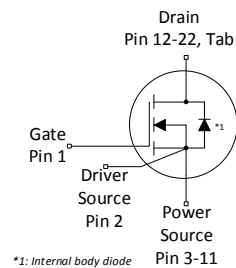
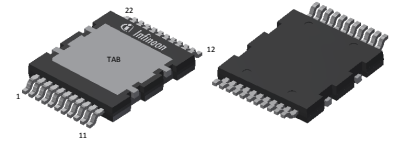




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## 1 Maximum ratings

at  $T_j = 25^\circ\text{C}$ , unless otherwise specified.

Note: 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           | Values |      |            | Unit             | Note / Test condition                                                                                               |
|------------------------------------------------|------------------|--------|------|------------|------------------|---------------------------------------------------------------------------------------------------------------------|
|                                                |                  | Min.   | Typ. | Max.       |                  |                                                                                                                     |
| Continuous DC drain current <sup>1)</sup>      | $I_{\text{DDC}}$ | -      | -    | 154<br>123 | A                | $T_c = 25^\circ\text{C}$<br>$T_c = 100^\circ\text{C}$                                                               |
| Peak drain current <sup>2)</sup>               | $I_{\text{DM}}$  | -      | -    | 567        | A                | $T_c = 25^\circ\text{C}$ , $V_{\text{GS}} = 18\text{ V}$                                                            |
| Avalanche energy, single pulse                 | $E_{\text{AS}}$  | -      | -    | 534        | mJ               | $I_D = 20\text{ A}$ , $V_{\text{DD}} = 50\text{ V}$ ; see table 11                                                  |
| Avalanche energy, repetitive                   | $E_{\text{AR}}$  | -      | -    | 2.67       | mJ               |                                                                                                                     |
| Avalanche current, single pulse                | $I_{\text{AS}}$  | -      | -    | 20.0       | A                | -                                                                                                                   |
| MOSFET $dv/dt$ ruggedness                      | $dv/dt$          | -      | -    | 200        | V/ns             | $V_{\text{DS}} = 0 \dots 400\text{ V}$                                                                              |
| Gate source voltage (static) <sup>3)</sup>     | $V_{\text{GS}}$  | -7     | -    | 23         | V                | -                                                                                                                   |
| Gate source voltage (transient)                | $V_{\text{GS}}$  | -10    | -    | 25         | V                | $t_p \leq 500\text{ ns}$ , duty cycle $\leq 1\%$                                                                    |
| Power dissipation                              | $P_{\text{tot}}$ | -      | -    | 651        | W                | $T_c = 25^\circ\text{C}$                                                                                            |
| Storage temperature                            | $T_{\text{stg}}$ | -55    | -    | 150        | $^\circ\text{C}$ | -                                                                                                                   |
| Operating junction temperature                 | $T_j$            | -55    | -    | 175        | $^\circ\text{C}$ |                                                                                                                     |
| Mounting torque                                | -                | -      | -    | n.a.       | Ncm              |                                                                                                                     |
| Continuous reverse drain current <sup>1)</sup> | $I_{\text{SDC}}$ | -      | -    | 154<br>117 | A                | $V_{\text{GS}} = 18\text{ V}$ , $T_c = 25^\circ\text{C}$<br>$V_{\text{GS}} = 0\text{ V}$ , $T_c = 25^\circ\text{C}$ |
| Peak reverse drain current <sup>2)</sup>       | $I_{\text{SM}}$  | -      | -    | 567<br>173 | A                | $T_c = 25^\circ\text{C}$ , $t_p \leq 250\text{ ns}$<br>$T_c = 25^\circ\text{C}$                                     |
| Insulation withstand voltage                   | $V_{\text{ISO}}$ | -      | -    | n.a.       | V                | $V_{\text{rms}}$ , $T_c = 25^\circ\text{C}$ , $t = 1\text{ min}$                                                    |

<sup>1)</sup> Limited by  $T_{j,\text{max}}$ .

<sup>2)</sup> Pulse width  $t_{\text{pulse}}$  limited by  $T_{j,\text{max}}$ .

<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             | $R_{th(j-c)}$ | -      | -    | 0.23 | °C/W | Not subject to production test.<br>Parameter verified by design/characterization according to JESD51-14. |
| Soldering temperature, reflow soldering allowed | $T_{solder}$  | -      | -    | 260  | °C   | reflow MSL3                                                                                              |

### 3 Operating range

**Table 4**    **Operating range**

| Parameter                    | Symbol        | Values |      |      | Unit | Note / Test condition |
|------------------------------|---------------|--------|------|------|------|-----------------------|
|                              |               | Min.   | Typ. | Max. |      |                       |
| Recommended turn-on voltage  | $V_{GS(on)}$  | -      | 18   | -    | V    | -                     |
| Recommended turn-off voltage | $V_{GS(off)}$ | -      | 0    | -    | V    |                       |

## 4 Electrical characteristics

at  $T_j = 25^\circ\text{C}$ , unless otherwise specified

**Table 5 Static characteristics**

| Parameter                            | Symbol              | Values |                           |                     | Unit             | Note / Test condition                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------------|---------------------|--------|---------------------------|---------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      |                     | Min.   | Typ.                      | Max.                |                  |                                                                                                                                                                                                                                                                                                                                                                                   |
| Drain-source voltage                 | $V_{\text{DSS}}$    | 650    | -                         | -                   | V                | $V_{\text{GS}} = 0\text{ V}$ , $I_{\text{D}} = 1.87\text{ mA}$                                                                                                                                                                                                                                                                                                                    |
| Gate threshold voltage <sup>4)</sup> | $V_{\text{GS(th)}}$ | 3.5    | 4.5                       | 5.6                 | V                | $V_{\text{DS}} = V_{\text{GS}}$ , $I_{\text{D}} = 18.7\text{ mA}$                                                                                                                                                                                                                                                                                                                 |
| Zero gate voltage drain current      | $I_{\text{DSS}}$    | -      | 1<br>10                   | 75<br>-             | $\mu\text{A}$    | $V_{\text{DS}} = 650\text{ V}$ , $V_{\text{GS}} = 0\text{ V}$ , $T_j = 25^\circ\text{C}$<br>$V_{\text{DS}} = 650\text{ V}$ , $V_{\text{GS}} = 0\text{ V}$ , $T_j = 175^\circ\text{C}$                                                                                                                                                                                             |
| Gate-source leakage current          | $I_{\text{GSS}}$    | -      | -                         | 100                 | nA               | $V_{\text{GS}} = 20\text{ V}$ , $V_{\text{DS}} = 0\text{ V}$                                                                                                                                                                                                                                                                                                                      |
| Drain-source on-state resistance     | $R_{\text{DS(on)}}$ | -      | 13.0<br>10.0<br>9.1<br>16 | -<br>13.1<br>-<br>- | $\text{m}\Omega$ | $V_{\text{GS}} = 15\text{ V}$ , $I_{\text{D}} = 92.1\text{ A}$ , $T_j = 25^\circ\text{C}$<br>$V_{\text{GS}} = 18\text{ V}$ , $I_{\text{D}} = 92.1\text{ A}$ , $T_j = 25^\circ\text{C}$<br>$V_{\text{GS}} = 20\text{ V}$ , $I_{\text{D}} = 92.1\text{ A}$ , $T_j = 25^\circ\text{C}$<br>$V_{\text{GS}} = 18\text{ V}$ , $I_{\text{D}} = 92.1\text{ A}$ , $T_j = 175^\circ\text{C}$ |
| Internal gate resistance             | $R_{\text{G,int}}$  | -      | 1.7                       | -                   | $\Omega$         | $f = 1\text{ MHz}$                                                                                                                                                                                                                                                                                                                                                                |

<sup>4)</sup> Tested after 1 ms pulse at  $V_{\text{GS}} = +20\text{ V}$ . "Linear mode" operation is not recommended. For assessment of potential "linear mode" operation, please contact Infineon sales office.

**Table 6 Dynamic characteristics**

External parasitic elements (PCB layout) influence switching behavior significantly.  
 Stray inductances and coupling capacitances must be minimized.  
 For layout recommendations please use provided application notes or contact Infineon sales office.

| Parameter                                                  | Symbol              | Values |      |      | Unit | Note / Test condition                                                                                                                                           |
|------------------------------------------------------------|---------------------|--------|------|------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                            |                     | Min.   | Typ. | Max. |      |                                                                                                                                                                 |
| Input capacitance                                          | $C_{\text{iss}}$    | -      | 4002 | -    | pF   | $V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 400\text{ V}$ , $f = 250\text{ kHz}$                                                                            |
| Reverse transfer capacitance                               | $C_{\text{rss}}$    | -      | 22   | -    | pF   |                                                                                                                                                                 |
| Output capacitance <sup>5)</sup>                           | $C_{\text{oss}}$    | -      | 297  | 386  | pF   |                                                                                                                                                                 |
| Output charge <sup>5)</sup>                                | $Q_{\text{oss}}$    | -      | 212  | 276  | nC   | calculation based on $C_{\text{oss}}$                                                                                                                           |
| Effective output capacitance, energy related <sup>6)</sup> | $C_{\text{o(er)}}$  | -      | 359  | -    | pF   | $V_{\text{GS}} = 0\text{ V}$ ,<br>$V_{\text{DS}} = 0 \dots 400\text{ V}$                                                                                        |
| Effective output capacitance, time related <sup>7)</sup>   | $C_{\text{o(tr)}}$  | -      | 531  | -    | pF   | $I_{\text{D}} = \text{constant}$ , $V_{\text{GS}} = 0\text{ V}$ , $V_{\text{DS}} = 0 \dots 400\text{ V}$                                                        |
| Turn-on delay time                                         | $t_{\text{d(on)}}$  | -      | 16   | -    | ns   | $V_{\text{DD}} = 400\text{ V}$ , $V_{\text{GS}} = 0/18\text{ V}$ ,<br>$I_{\text{D}} = 92.1\text{ A}$ , $R_{\text{G,ext}} = 3.3\text{ }\Omega$ ;<br>see table 10 |
| Rise time                                                  | $t_{\text{r}}$      | -      | 24   | -    | ns   |                                                                                                                                                                 |
| Turn-off delay time                                        | $t_{\text{d(off)}}$ | -      | 30   | -    | ns   |                                                                                                                                                                 |
| Fall time                                                  | $t_{\text{f}}$      | -      | 9.4  | -    | ns   |                                                                                                                                                                 |

**Table 6 Dynamic characteristics**

External parasitic elements (PCB layout) influence switching behavior significantly.  
 Stray inductances and coupling capacitances must be minimized.  
 For layout recommendations please use provided application notes or contact Infineon sales office.

| Parameter                               | Symbol    | Values |      |      | Unit | Note / Test condition                                                                                     |
|-----------------------------------------|-----------|--------|------|------|------|-----------------------------------------------------------------------------------------------------------|
|                                         |           | Min.   | Typ. | Max. |      |                                                                                                           |
| Turn-ON switching losses <sup>8)</sup>  | $E_{on}$  | -      | 216  | -    | μJ   | $V_{DD} = 400\text{ V}$ , $V_{GS} = 0/18\text{ V}$ ,<br>$I_D = 92.1\text{ A}$ , $R_{G,ext} = 3.3\ \Omega$ |
| Turn-OFF switching losses <sup>8)</sup> | $E_{off}$ | -      | 371  | -    | μJ   |                                                                                                           |
| Total switching losses <sup>8)</sup>    | $E_{tot}$ | -      | 587  | -    | μJ   |                                                                                                           |

<sup>5)</sup> Maximum specification is defined by calculated six sigma upper confidence bound.

<sup>6)</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>7)</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.

<sup>8)</sup> Values for 4-pin configuration based on TO-263-7 measurements; MOSFET used in half-bridge configuration without external diode.

**Table 7 Gate charge characteristics**

| Parameter                     | Symbol       | Values |      |      | Unit | Note / Test condition                                                                   |
|-------------------------------|--------------|--------|------|------|------|-----------------------------------------------------------------------------------------|
|                               |              | Min.   | Typ. | Max. |      |                                                                                         |
| Plateau gate to source charge | $Q_{GS(pl)}$ | -      | 29   | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_D = 92.1\text{ A}$ ,<br>$V_{GS} = 0\text{ to }18\text{ V}$ |
| Gate to drain charge          | $Q_{GD}$     | -      | 21   | -    | nC   |                                                                                         |
| Total gate charge             | $Q_G$        | -      | 113  | -    | nC   |                                                                                         |

**Table 8 Reverse diode characteristics**

| Parameter                                    | Symbol    | Values |            |      | Unit | Note / Test condition                                                                                                                                                                                                |
|----------------------------------------------|-----------|--------|------------|------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                              |           | Min.   | Typ.       | Max. |      |                                                                                                                                                                                                                      |
| Drain-source reverse voltage                 | $V_{SD}$  | -      | 4.3        | -    | V    | $V_{GS} = 0\text{ V}$ , $I_S = 92.1\text{ A}$ , $T_J = 25^\circ\text{C}$                                                                                                                                             |
| MOSFET forward recovery time                 | $t_{fr}$  | -      | 25<br>19   | -    | ns   | $V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9<br>$V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 4000\text{ A}/\mu\text{s}$ ; see table 9 |
| MOSFET forward recovery charge <sup>9)</sup> | $Q_{fr}$  | -      | 224<br>376 | -    | nC   | $V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9<br>$V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 4000\text{ A}/\mu\text{s}$ ; see table 9 |
| MOSFET peak forward recovery current         | $I_{frm}$ | -      | 18<br>40   | -    | A    | $V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 1000\text{ A}/\mu\text{s}$ ; see table 9<br>$V_{DD} = 400\text{ V}$ , $I_S = 92.1\text{ A}$ ,<br>$di_S/dt = 4000\text{ A}/\mu\text{s}$ ; see table 9 |

<sup>9)</sup>  $Q_{fr}$  includes  $Q_{oss}$ .

## 5 Electrical characteristics diagrams

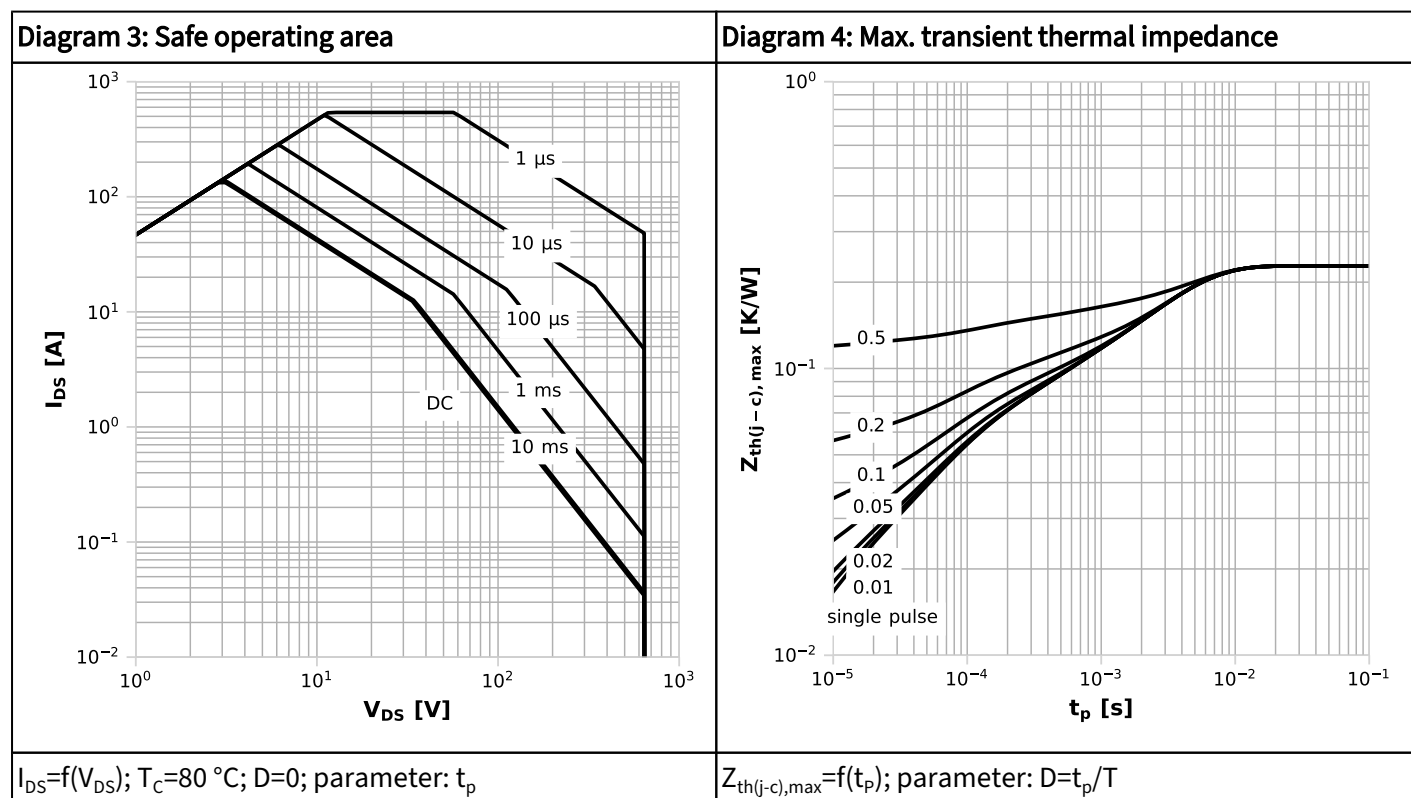
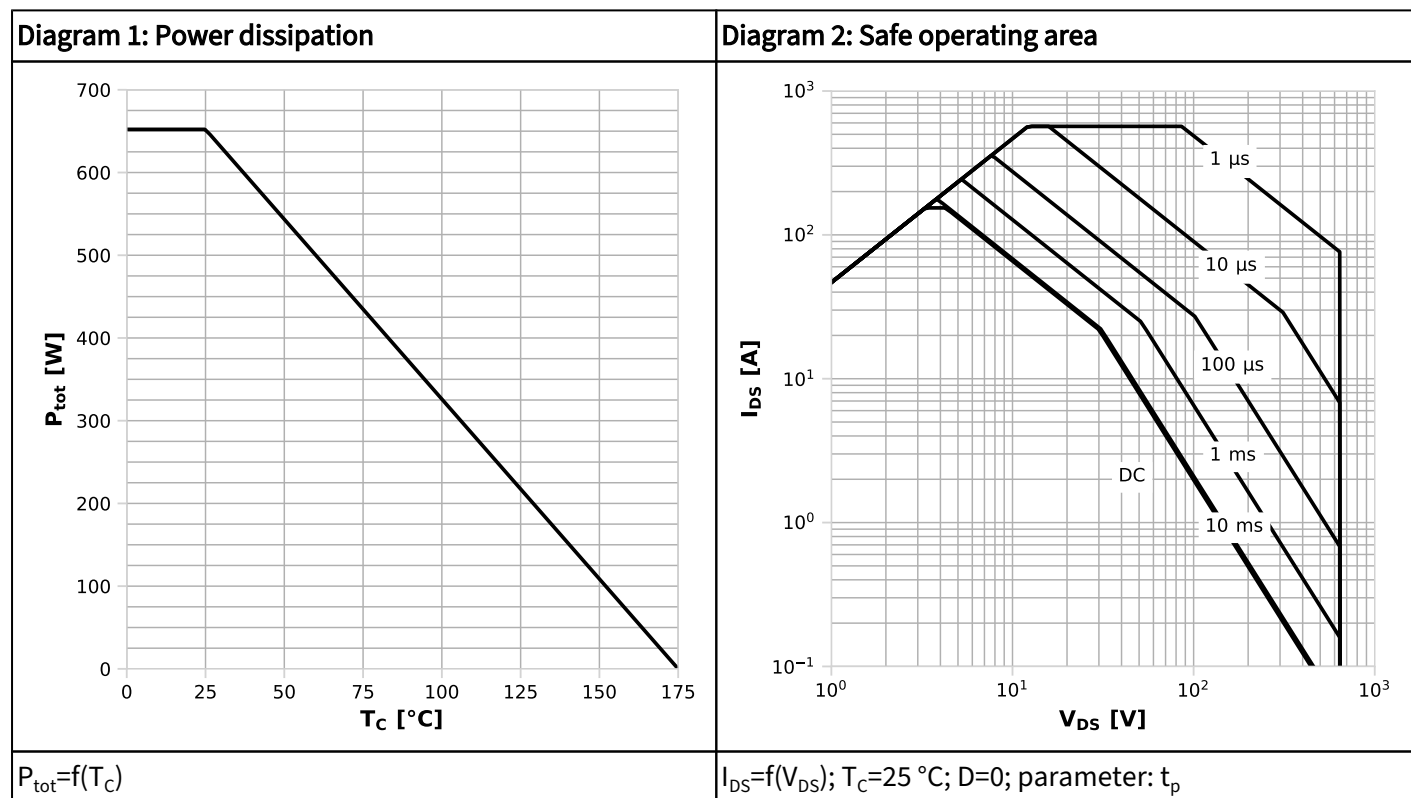
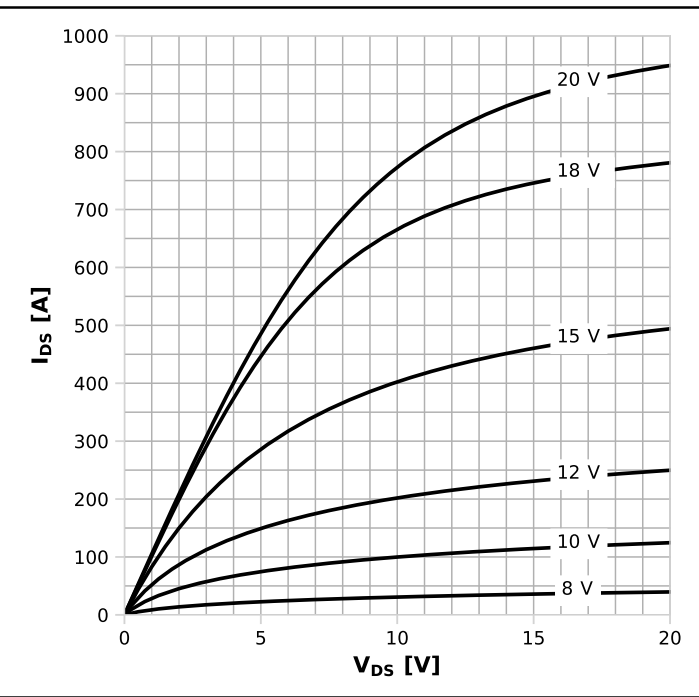
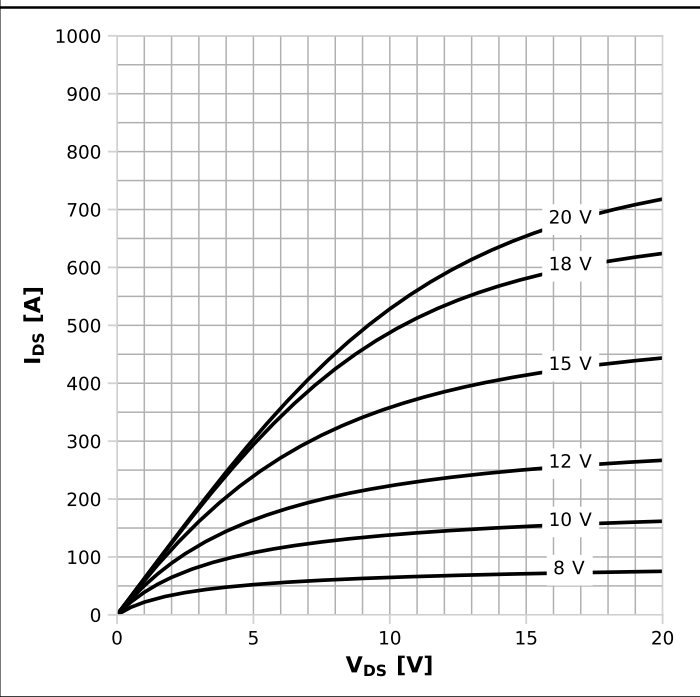


Diagram 5: Typ. output characteristics



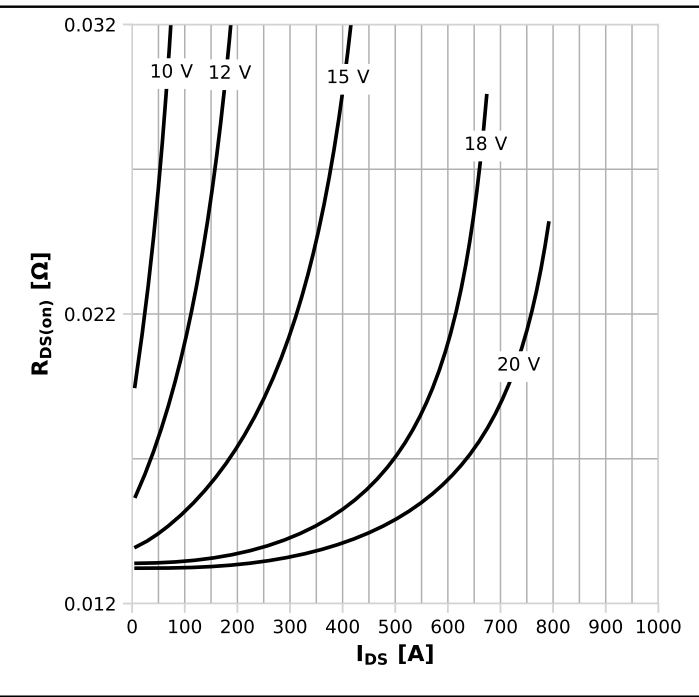
$I_{DS}=f(V_{DS})$ ;  $T_j=25\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. output characteristics



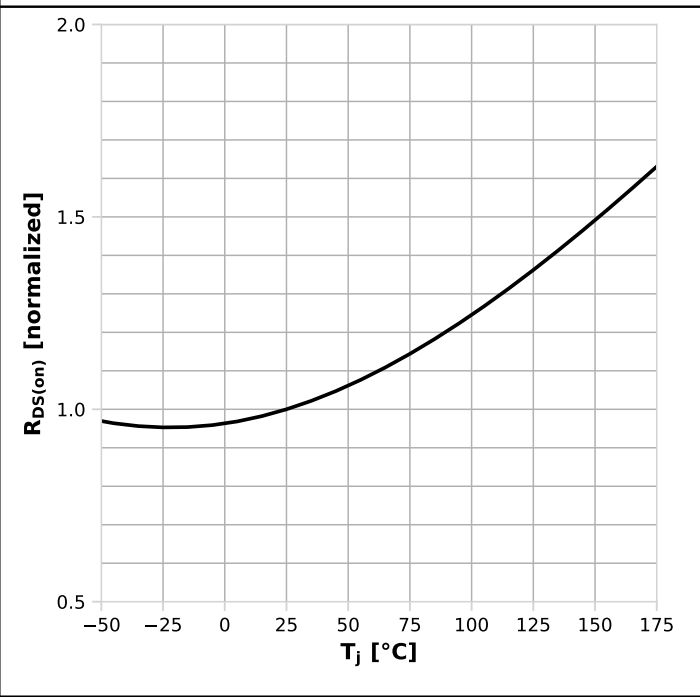
$I_{DS}=f(V_{DS})$ ;  $T_j=175\text{ °C}$ ; parameter:  $V_{GS}$

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



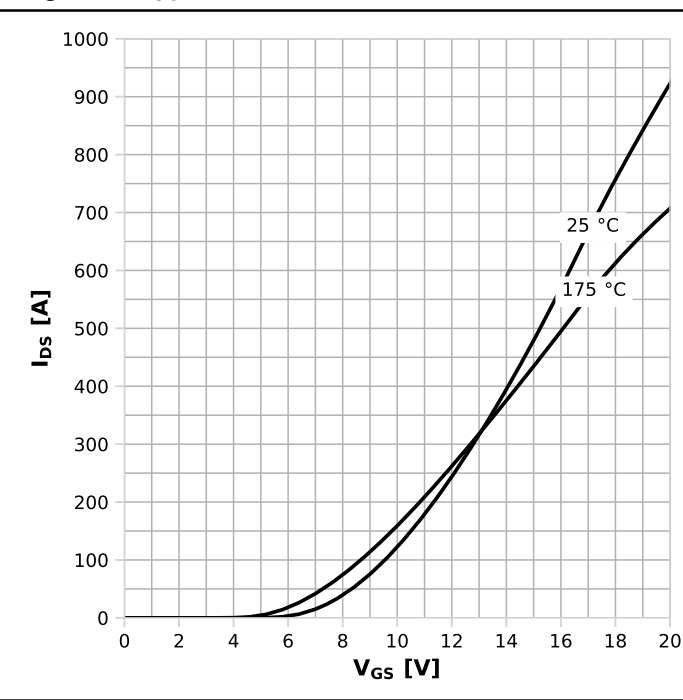
$R_{DS(on)}=f(I_{DS})$ ;  $T_j=125\text{ °C}$ ; parameter:  $V_{GS}$

Diagram 8: Drain-source on-state resistance



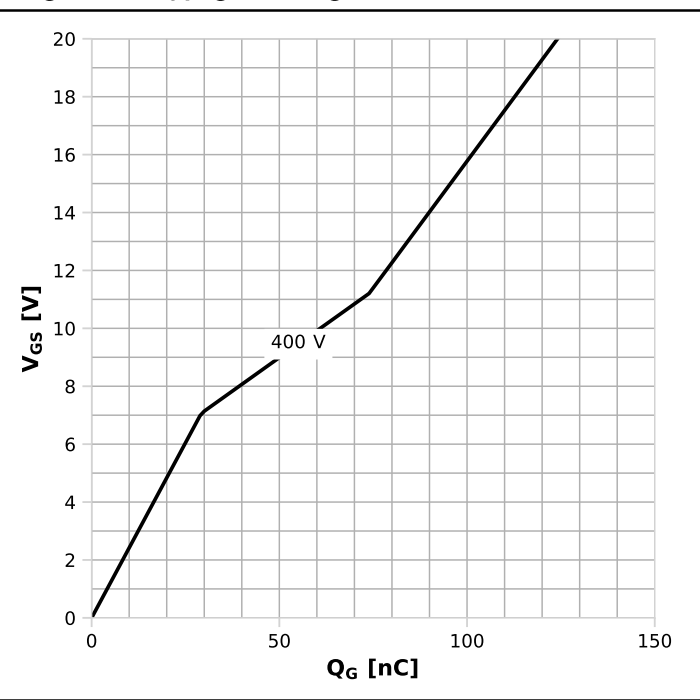
$R_{DS(on)}=f(T_j)$ ;  $I_D=92.1\text{ A}$ ;  $V_{GS}=18\text{ V}$

Diagram 9: Typ. transfer characteristics



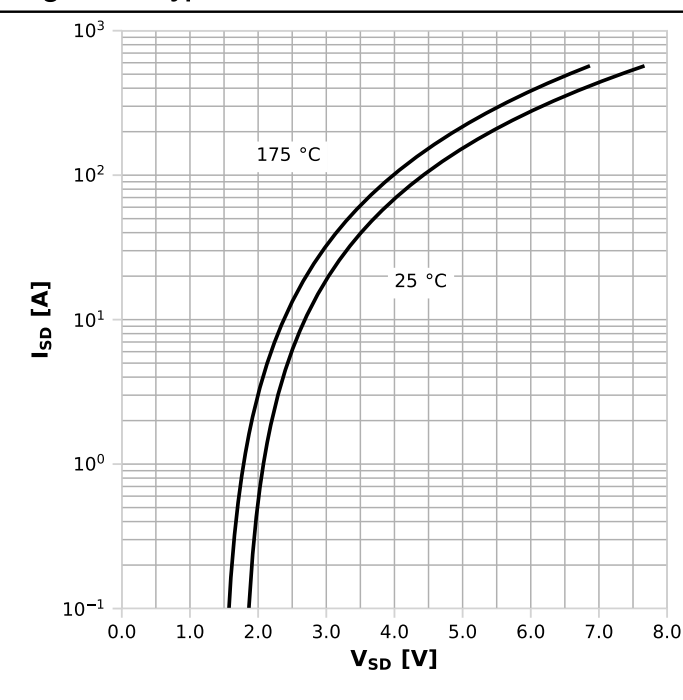
$I_{DS}=f(V_{GS})$ ;  $V_{DS}=20$  V; parameter:  $T_j$

Diagram 10: Typ. gate charge



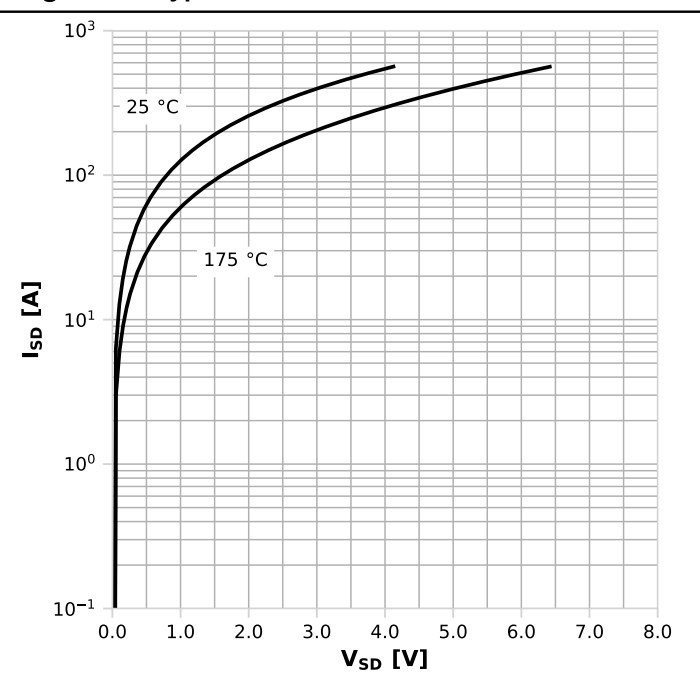
$V_{GS}=f(Q_G)$ ;  $I_D=92.1$  A pulsed; parameter:  $V_{DD}$

Diagram 11: Typ. reverse drain current characteristics



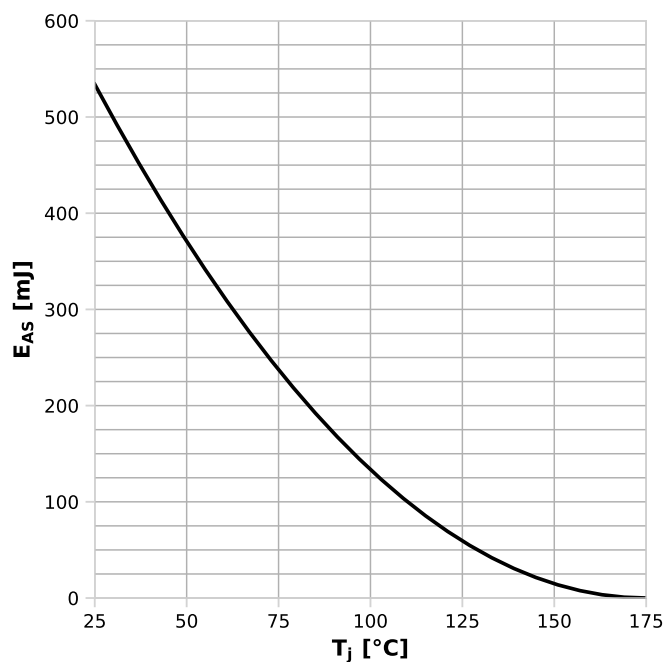
$I_{SD}=f(V_{SD})$ ;  $V_{GS}=0$  V; parameter:  $T_j$

Diagram 12: Typ. reverse drain current characteristics



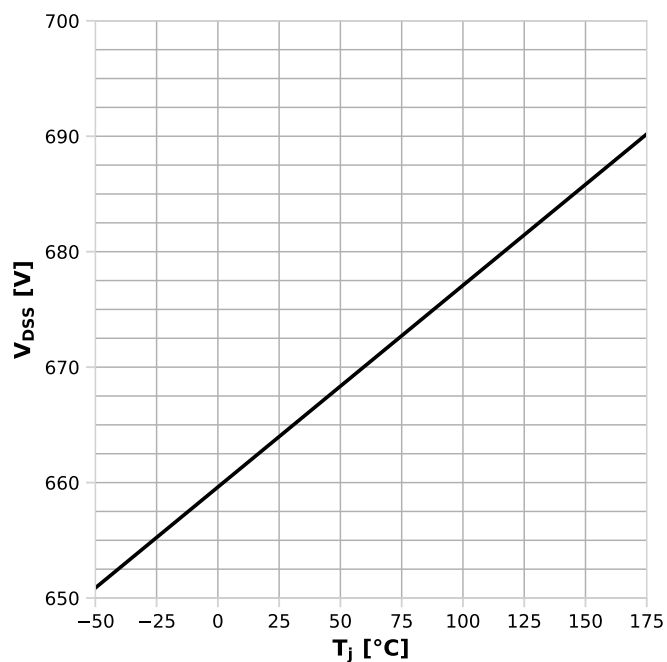
$I_{SD}=f(V_{SD})$ ;  $V_{GS}=18$  V; parameter:  $T_j$

Diagram 13: Avalanche energy



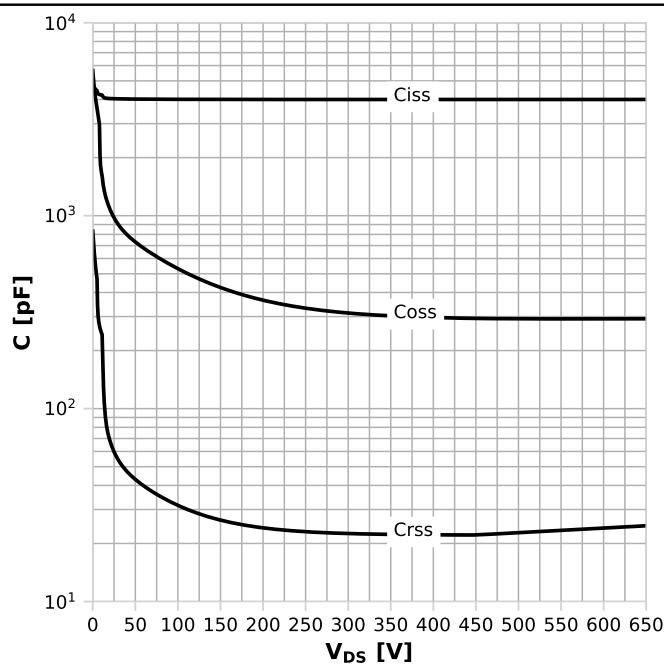
$$E_{AS}=f(T_J); I_D=20.0 \text{ A}; V_{DD}=50 \text{ V}$$

Diagram 14: Drain-source breakdown voltage



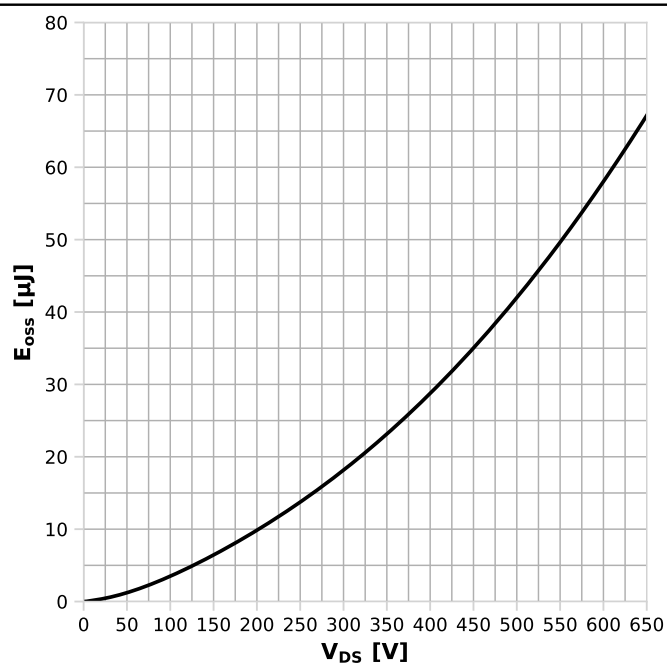
$$V_{DSS}=f(T_J); I_D=1.87 \text{ mA}$$

Diagram 15: Typ. capacitances



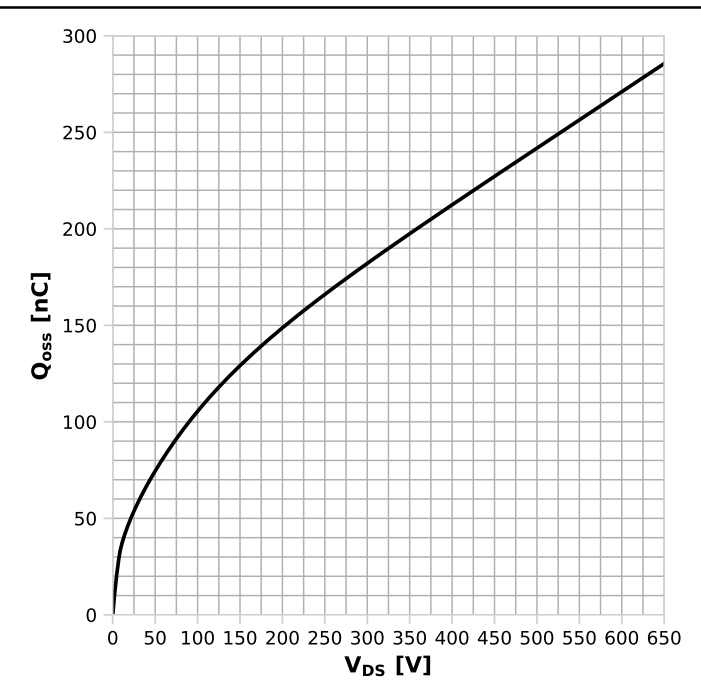
$$C=f(V_{DS}); V_{GS}=0 \text{ V}; f=250 \text{ kHz}$$

Diagram 16: Typ. Coss stored energy



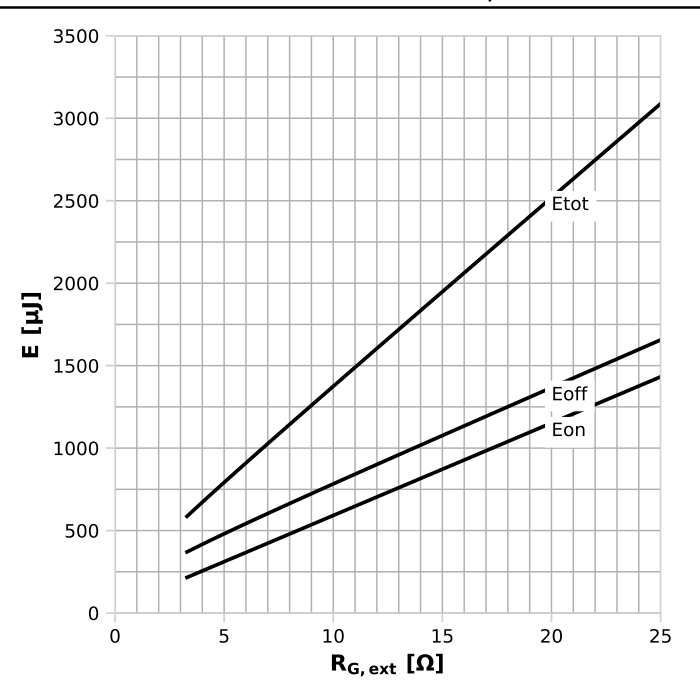
$$E_{OSS}=f(V_{DS})$$

Diagram 17: Typ. Qoss output charge



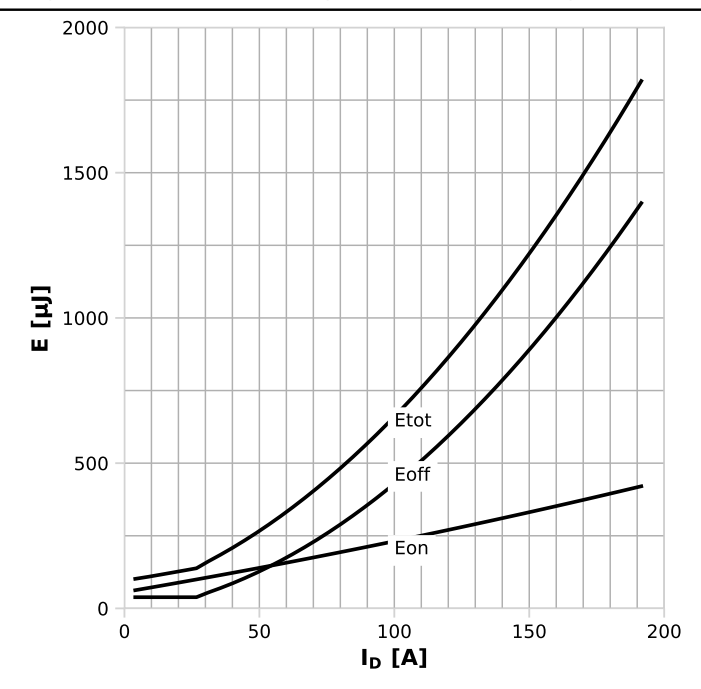
$Q_{oss}=f(V_{DS})$

Diagram 18: Typ. Switching Losses vs  $R_{G,ext}$



$E=f(R_{G,ext}); V_{DD}=400\text{ V}; V_{GS}=0-18\text{ V}; I_D=92.1\text{ A}$

Diagram 19: Typ. Switching Losses vs switching current



$E=f(I_D); V_{DD}=400\text{ V}; V_{GS}=0-18\text{ V}; R_{G,ext}=3.3\text{ }\Omega$

6 Test circuits

Table 9 Body diode characteristics



Table 10 Switching times



Table 11 Unclamped inductive load



## 7 Package outlines

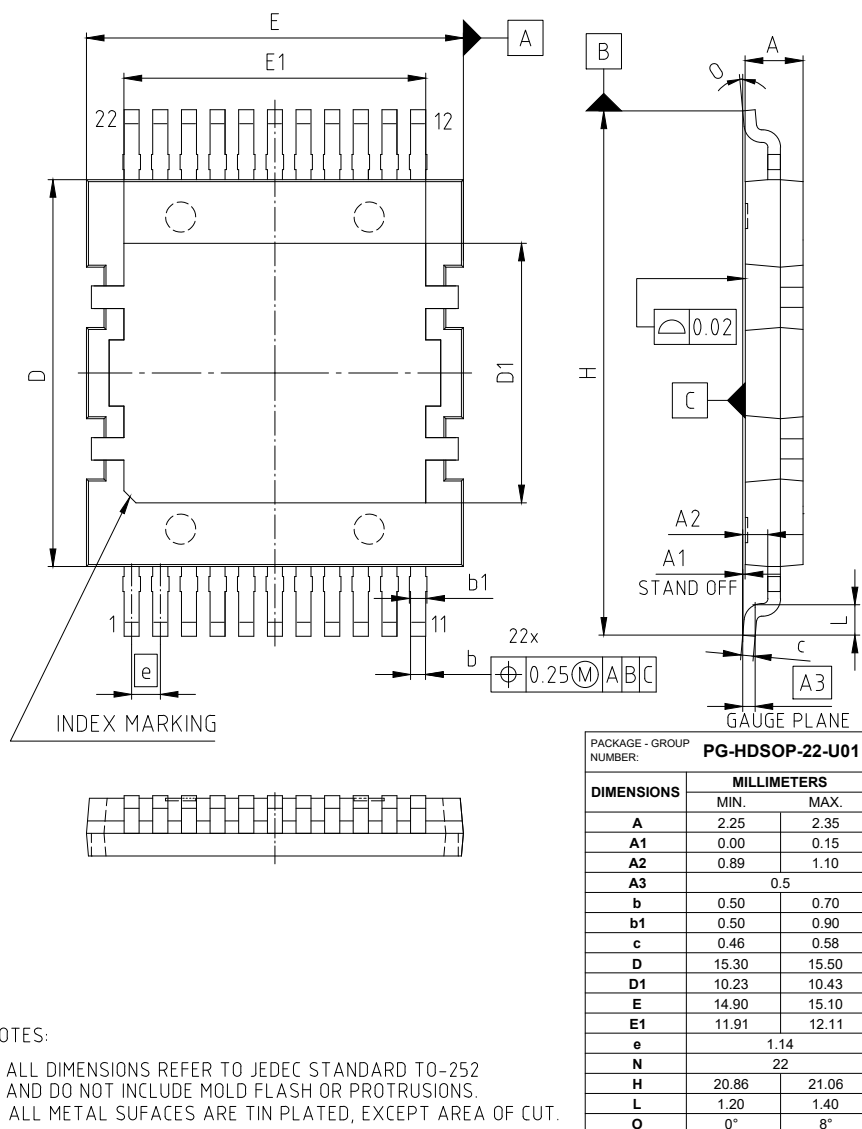
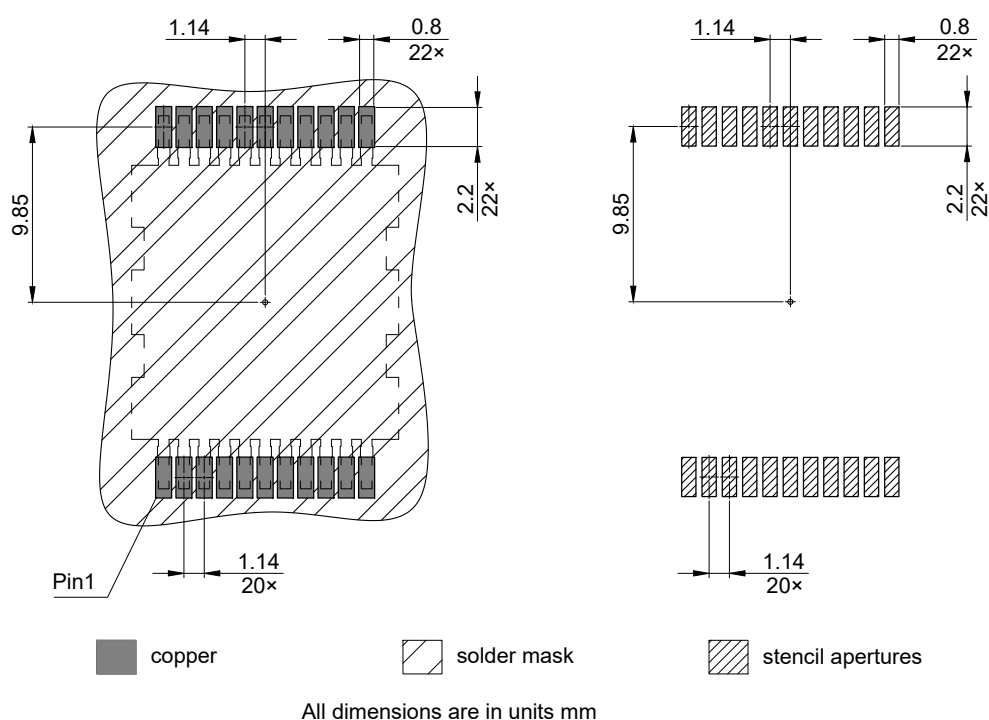
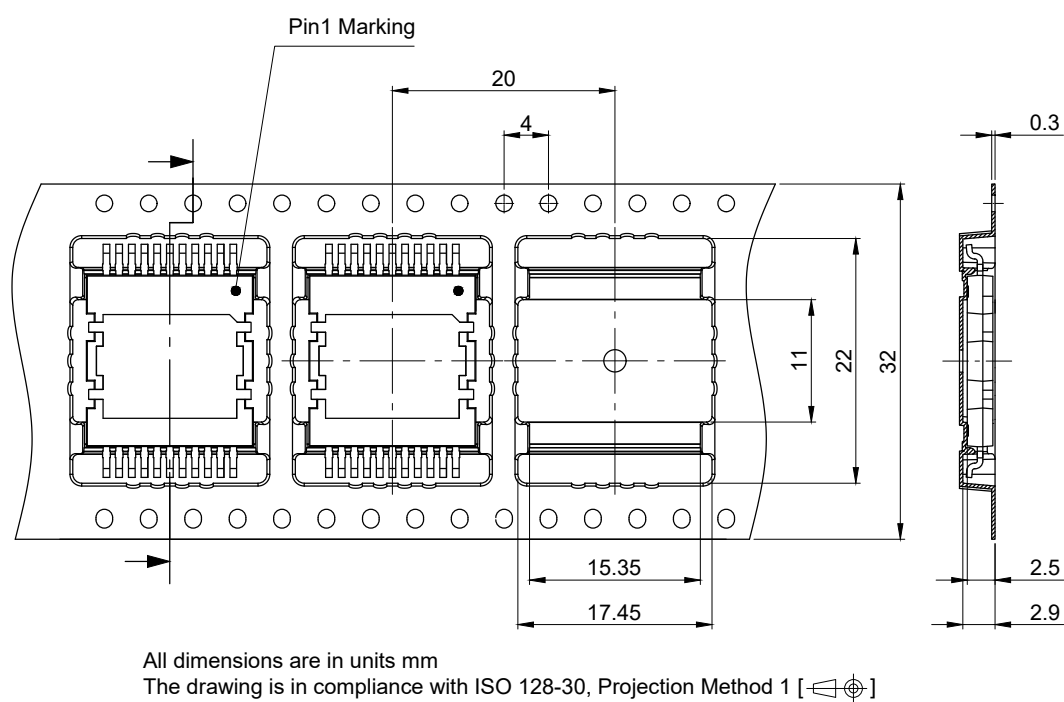


Figure 1 Outline PG-HDSOP-22, dimensions in mm



**Figure 2** Footprint drawing PG-HDSOP-22, dimensions in mm



**Figure 3** Packaging variant PG-HDSOP-22, dimensions in mm

## 8 Appendix A

**Table 12**    **Related links**

- [IFX CoolSiC CoolSiC™ MOSFET 650 V G2 Webpage](#)
- [IFX CoolSiC CoolSiC™ MOSFET 650 V G2 Application Note](#)
- [IFX CoolSiC CoolSiC™ MOSFET 650 V G2 Simulation Model](#)
- [IFX Design tools](#)

## Revision history

IMDQ65R010M2H

### Revision 2025-01-16, Rev. 2.1

Previous revisions

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 2.0      | 2024-11-06 | Release of final                             |
| 2.1      | 2025-01-16 | updated continuous reverse drain current     |

### Trademarks

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