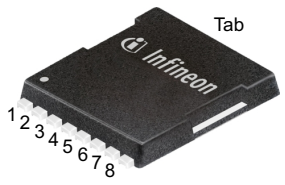
# MOSFET

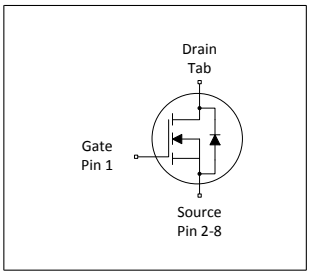
## OptiMOS™ 6 Power-Transistor, 135 V

TOLL




### Features

- N-channel, normal level
- Very low on-resistance $R_{DS(on)}$
- Excellent gate charge x $R_{DS(on)}$ product (FOM)
- Very low reverse recovery charge ($Q_{rr}$)
- 100% avalanche tested
- 175°C operating temperature
- Optimized for motor drives and battery powered applications
- Pb-free lead plating; RoHS compliant
- Halogen-free according to IEC61249-2-21
- MSL 1 classified according to J-STD-020




### Product validation

Fully qualified according to JEDEC for Industrial Applications

### Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|---|---|---|
| $V_{DS}$ | 135 | V |
| $R_{DS(on),max}$ | 2.0 | mΩ |
| $I_D$ | 297 | A |
| $Q_{oss}$ | 274 | nC |
| $Q_G$ | 159 | nC |
| $Q_{rr}$ (500 A/µs) | 154 | nC |

| Type / Ordering Code | Package | Marking | Related Links |
|---|---|---|---|
| IPT020N13NM6 | PG-HSOF-8 | 020N13N6 | - |

## Table of Contents

# 1 Maximum ratings

at $T_A$=25 °C, unless otherwise specified

## Table 2 Maximum ratings

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Continuous drain current[1] | $I_D$ | -<br>-<br>-<br>- | -<br>-<br>-<br>- | 297<br>210<br>196<br>29 | A | $V_{GS}$=10 V, $T_C$=25 °C<br>$V_{GS}$=10 V, $T_C$=100 °C<br>$V_{GS}$=8 V, $T_C$=100 °C<br>$V_{GS}$=10 V, $T_A$=25 °C, $R_{THJA}$=40 °C/W[2] |
| Pulsed drain current[3] | $I_{D,pulse}$ | - | - | 1188 | A | $T_C$=25 °C |
| Avalanche current, single pulse[4] | $I_{AS}$ | - | - | 142 | A | $T_C$=25 °C |
| Avalanche energy, single pulse[4] | $E_{AS}$ | - | - | 832 | mJ | $I_D$=69 A, $R_{GS}$=25 Ω |
| Gate source voltage | $V_{GS}$ | -20 | - | 20 | V | - |
| Power dissipation | $P_{tot}$ | -<br>- | -<br>- | 395<br>3.8 | W | $T_C$=25 °C<br>$T_A$=25 °C, $R_{THJA}$=40 °C/W[2] |
| Operating and storage temperature | $T_j$, $T_{stg}$ | -55 | - | 175 | °C | - |

# 2 Thermal characteristics

## Table 3 Thermal characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | $R_{thJC}$ | - | - | 0.4 | °C/W | - |
| Thermal resistance, junction - ambient, 6 cm² cooling area[2] | $R_{thJA}$ | - | - | 40 | °C/W | - |
| Thermal resistance, junction - ambient, minimal footprint | $R_{thJA}$ | - | - | 62 | °C/W | - |

[1] Rating refers to the product only with datasheet specified absolute maximum values, maintaining case temperature as specified. For other case temperatures please refer to Diagram 2. De-rating will be required based on the actual environmental conditions.
[2] Device on 40 mm x 40 mm x 1.5 mm epoxy PCB FR4 with 6 cm² (one layer, 70 µm thick) copper area for drain connection. PCB is vertical in still air.
[3] See Diagram 3 for more detailed information.
[4] See Diagram 13 for more detailed information.

# 3 Electrical characteristics

at $T_j$=25 °C, unless otherwise specified

## Table 4 Static characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | 135 | - | - | V | $V_{GS}$=0 V, $I_D$=1 mA |
| Gate threshold voltage | $V_{GS(th)}$ | 2.5 | 3 | 3.5 | V | $V_{DS}$=$V_{GS}$, $I_D$=275 µA |
| Zero gate voltage drain current | $I_{DSS}$ | -<br>- | 1<br>10 | 10<br>100 | µA | $V_{DS}$=108 V, $V_{GS}$=0 V, $T_j$=25 °C<br>$V_{DS}$=108 V, $V_{GS}$=0 V, $T_j$=125 °C |
| Gate-source leakage current | $I_{GSS}$ | - | 10 | 100 | nA | $V_{GS}$=20 V, $V_{DS}$=0 V |
| Drain-source on-state resistance | $R_{DS(on)}$ | -<br>-<br>- | 1.6<br>1.7<br>1.8 | 1.95<br>2.0<br>2.3 | mΩ | $V_{GS}$=15 V, $I_D$=142 A<br>$V_{GS}$=10 V, $I_D$=142 A<br>$V_{GS}$=8 V, $I_D$=71 A |
| Gate resistance[1)] | $R_G$ | - | 1.1 | 1.7 | Ω | - |
| Transconductance[1)] | $g_{fs}$ | 140 | 280 | - | S | $\|V_{DS}\|\geq 2\|I_D\|R_{DS(on)max}$, $I_D$=142 A |

## Table 5 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Input capacitance[1)] | $C_{iss}$ | - | 11000 | 14000 | pF | $V_{GS}$=0 V, $V_{DS}$=68 V, $f$=1 MHz |
| Output capacitance[1)] | $C_{oss}$ | - | 2200 | 2900 | pF | $V_{GS}$=0 V, $V_{DS}$=68 V, $f$=1 MHz |
| Reverse transfer capacitance[1)] | $C_{rss}$ | - | 28 | 49 | pF | $V_{GS}$=0 V, $V_{DS}$=68 V, $f$=1 MHz |
| Turn-on delay time | $t_{d(on)}$ | - | 21 | - | ns | $V_{DD}$=68 V, $V_{GS}$=10 V, $I_D$=71 A, $R_{G,ext}$=1.6 Ω |
| Rise time | $t_r$ | - | 17 | - | ns | $V_{DD}$=68 V, $V_{GS}$=10 V, $I_D$=71 A, $R_{G,ext}$=1.6 Ω |
| Turn-off delay time | $t_{d(off)}$ | - | 48 | - | ns | $V_{DD}$=68 V, $V_{GS}$=10 V, $I_D$=71 A, $R_{G,ext}$=1.6 Ω |
| Fall time | $t_f$ | - | 22 | - | ns | $V_{DD}$=68 V, $V_{GS}$=10 V, $I_D$=71 A, $R_{G,ext}$=1.6 Ω |

## Table 6 Gate charge characteristics[2)]

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge[1)] | $Q_{gs}$ | - | 49 | 64 | nC | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Gate charge at threshold | $Q_{g(th)}$ | - | 33 | - | nC | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Gate to drain charge[1)] | $Q_{gd}$ | - | 30 | 45 | nC | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Switching charge | $Q_{sw}$ | - | 47 | - | nC | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Gate charge total[1)] | $Q_g$ | - | 159 | 207 | nC | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Gate plateau voltage | $V_{plateau}$ | - | 4.5 | - | V | $V_{DD}$=68 V, $I_D$=71 A, $V_{GS}$=0 to 10 V |
| Gate charge total, sync. FET | $Q_{g(sync)}$ | - | 145 | - | nC | $V_{DS}$=0.1 V, $V_{GS}$=0 to 10 V |
| Output charge[1)] | $Q_{oss}$ | - | 274 | 356 | nC | $V_{DS}$=68 V, $V_{GS}$=0 V |

[1)] Defined by design. Not subject to production test.
[2)] See ″Gate charge waveforms″ for parameter definition

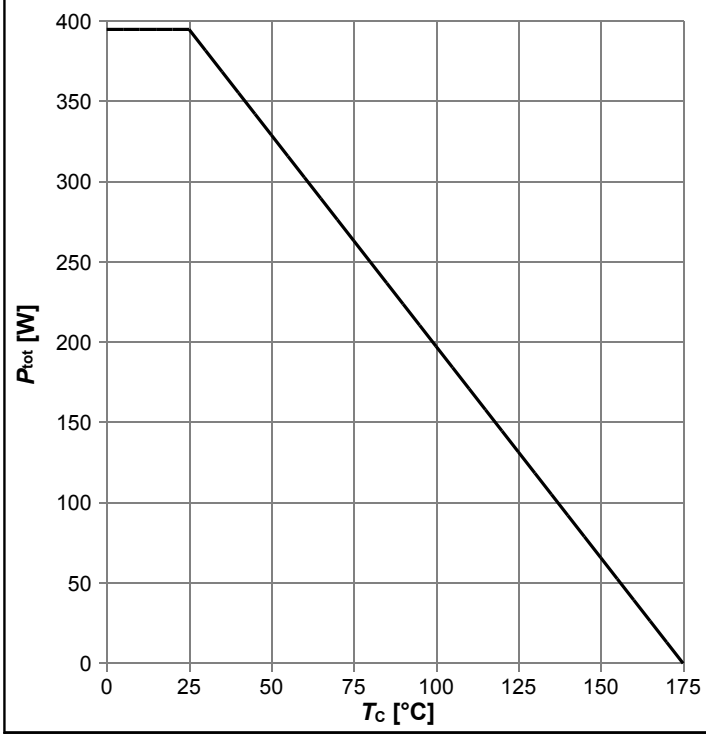
## Table 7 Reverse diode

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Diode continuous forward current | $I_S$ | - | - | 297 | A | $T_C$=25 °C |
| Diode pulse current | $I_{S,pulse}$ | - | - | 1188 | A | $T_C$=25 °C |
| Diode forward voltage | $V_{SD}$ | - | 0.87 | 1 | V | $V_{GS}$=0 V, $I_F$=142 A, $T_j$=25 °C |
| Reverse recovery time[1)] | $t_{rr}$ | - | 36 | 72 | ns | $V_R$=68 V, $I_F$=71 A, d$i_F$/d$t$=500 A/µs |
| Reverse recovery charge[1)] | $Q_{rr}$ | - | 154 | 308 | nC | $V_R$=68 V, $I_F$=71 A, d$i_F$/d$t$=500 A/µs |

[1)] Defined by design. Not subject to production test.

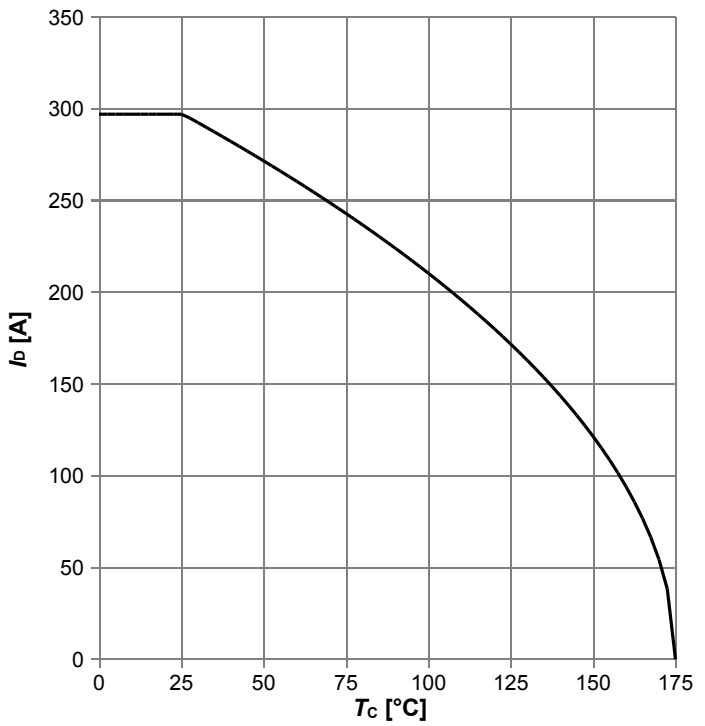
# 4 Electrical characteristics diagrams

**Diagram 1: Power dissipation**



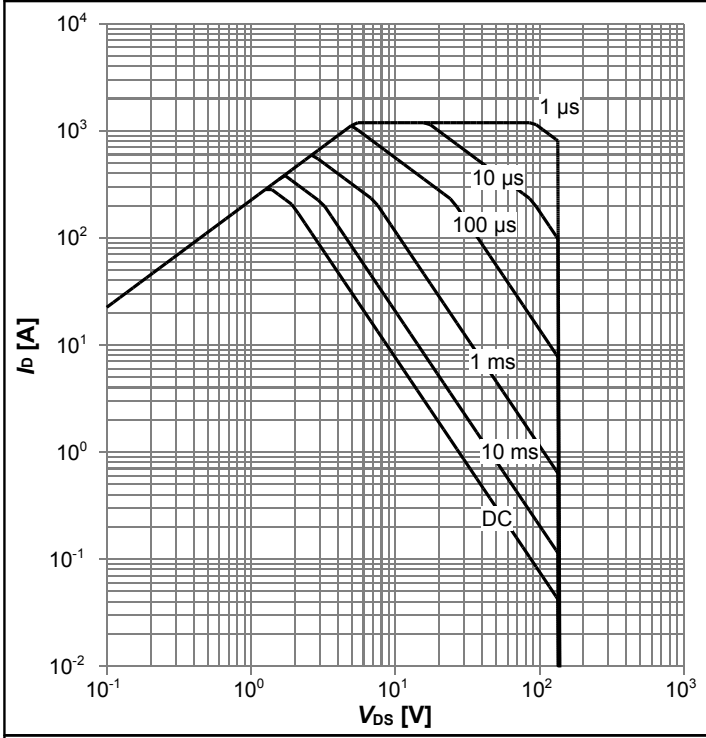

$P_{tot}=f(T_C)$

**Diagram 2: Drain current**



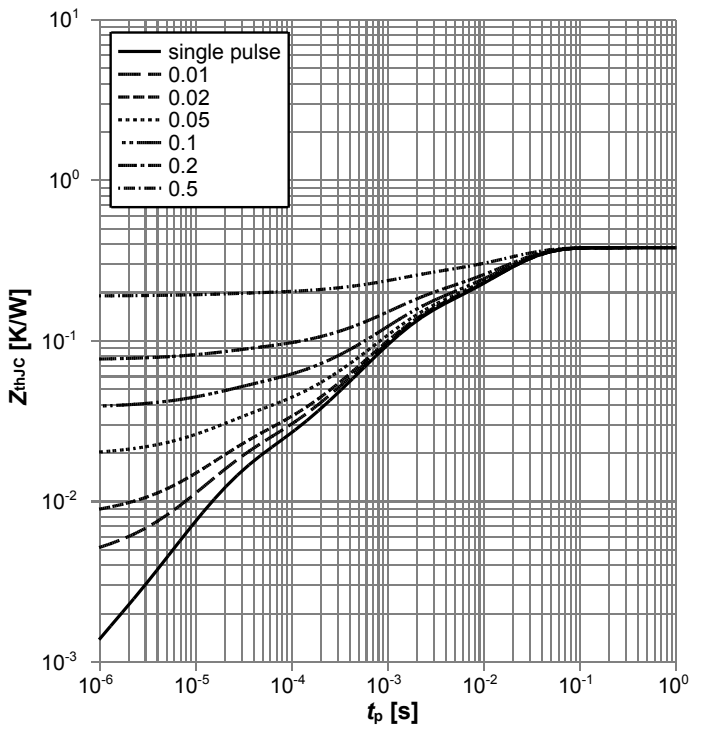

$I_D=f(T_C)$; $V_{GS}\geq 10$ V

**Diagram 3: Safe operating area**



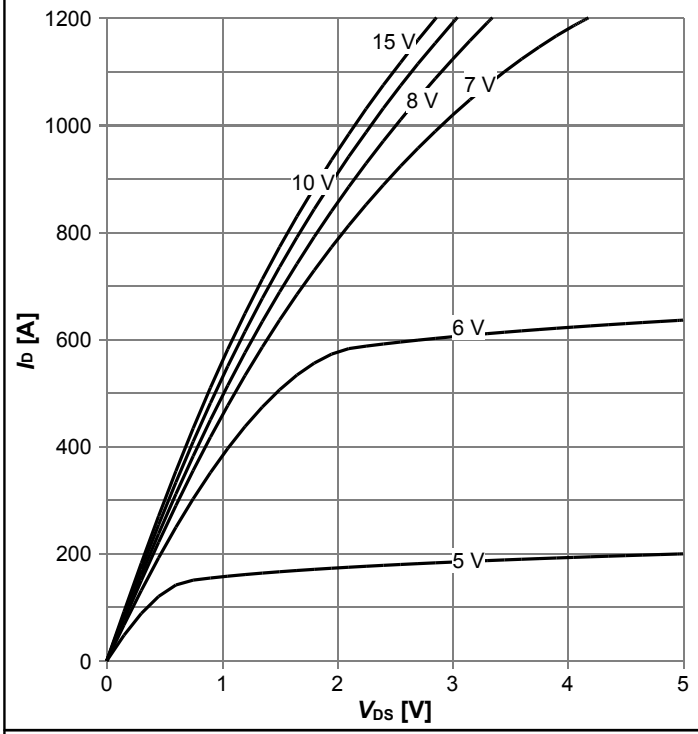

$I_D=f(V_{DS})$; $T_C=25$ °C; $D=0$; parameter: $t_p$

**Diagram 4: Max. transient thermal impedance**



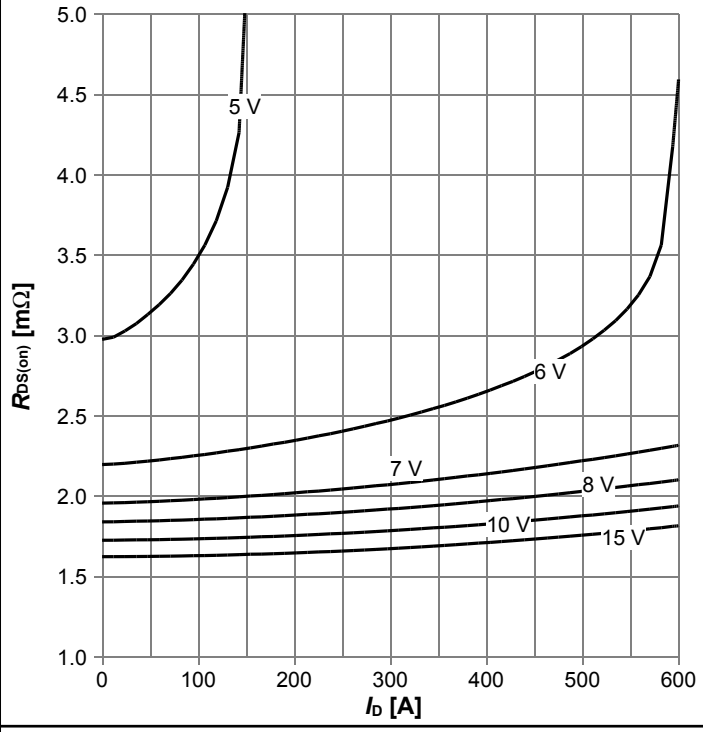

$Z_{thJC}=f(t_p)$; parameter: $D=t_p/T$

**Diagram 5: Typ. output characteristics**



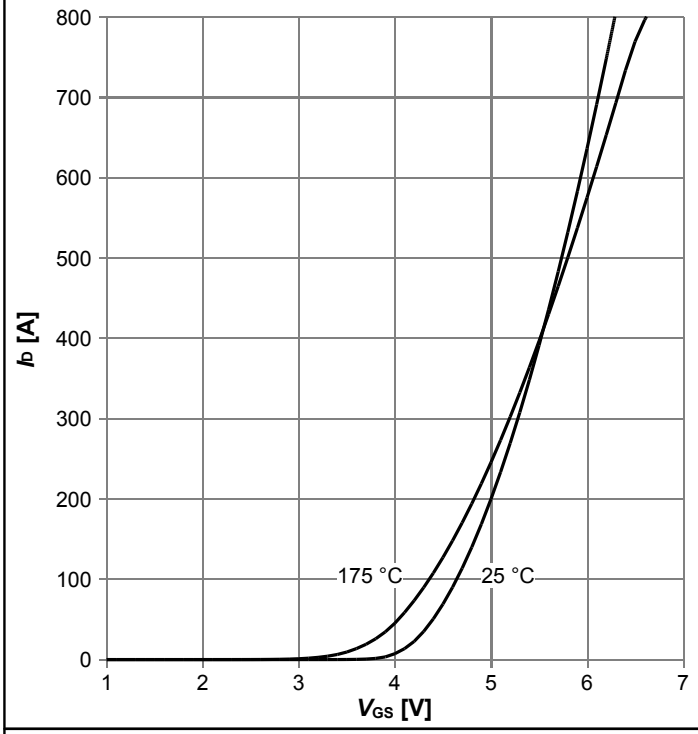

$I_D$=f($V_{DS}$), $T_j$=25 °C; parameter: $V_{GS}$

**Diagram 6: Typ. drain-source on resistance**



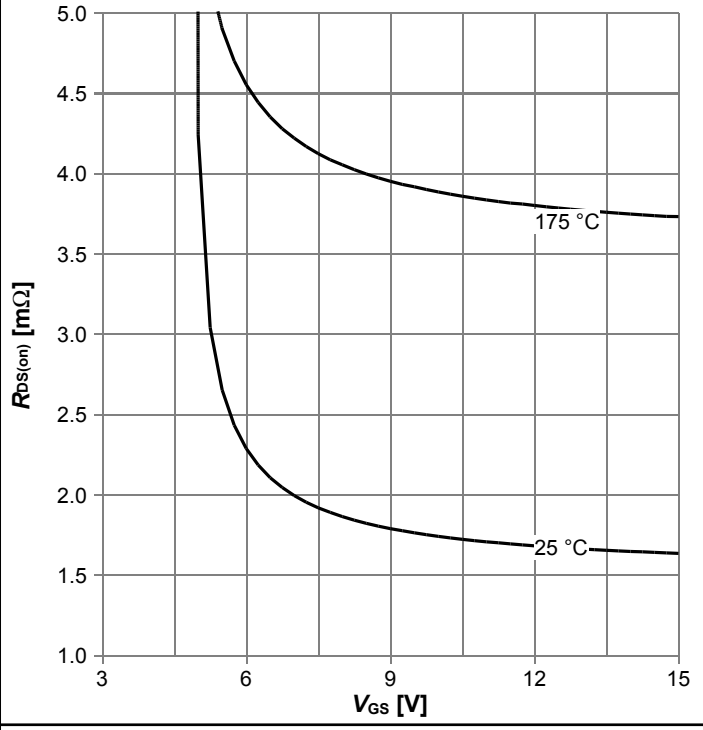

$R_{DS(on)}$=f($I_D$), $T_j$=25 °C; parameter: $V_{GS}$

**Diagram 7: Typ. transfer characteristics**



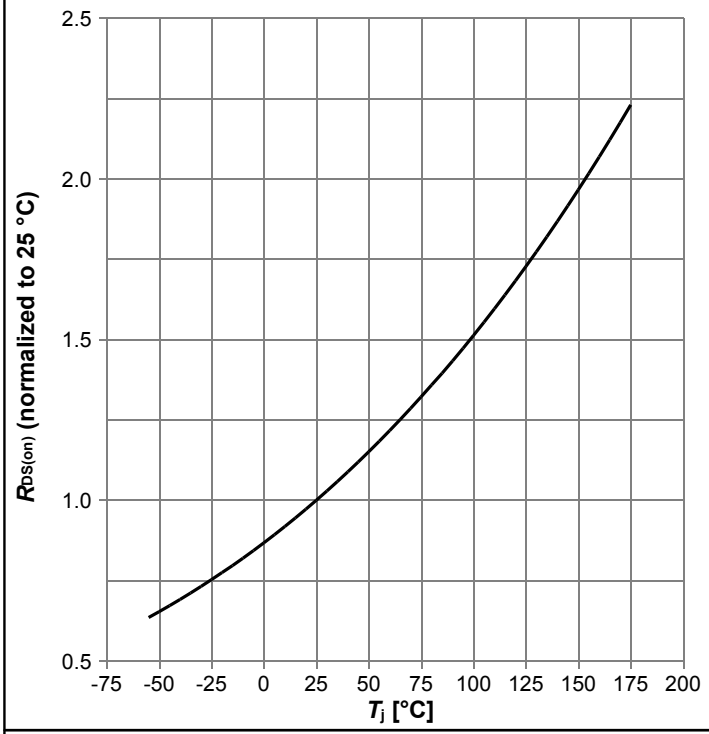

$I_D$=f($V_{GS}$), |$V_{DS}$|>2|$I_D$|$R_{DS(on)max}$; parameter: $T_j$

**Diagram 8: Typ. drain-source on resistance**



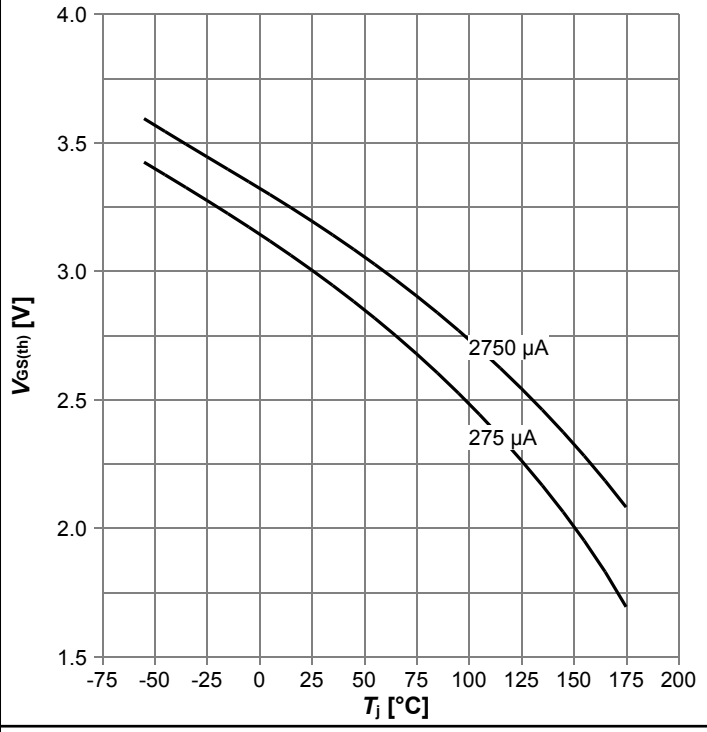

$R_{DS(on)}$=f($V_{GS}$), $I_D$=142 A; parameter: $T_j$

**Diagram 9: Normalized drain-source on resistance**



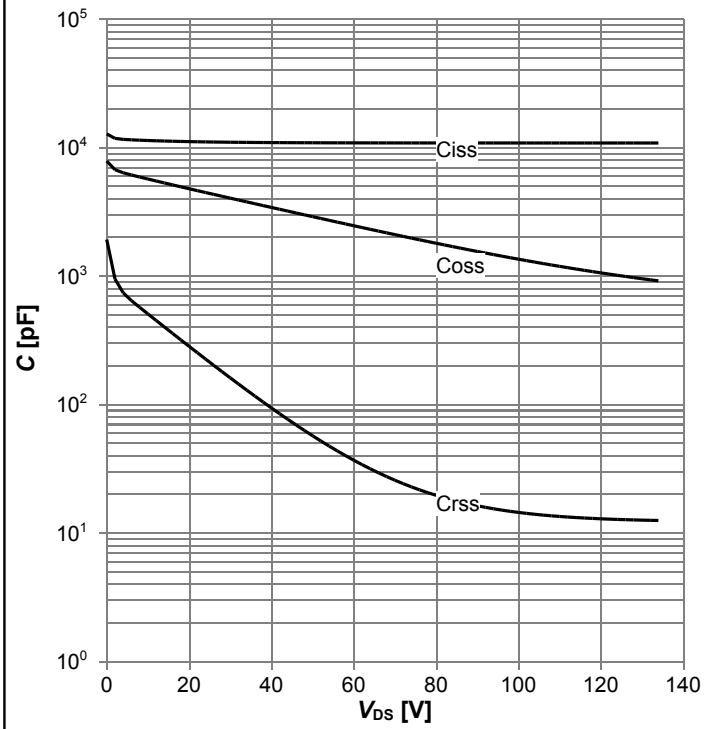

$R_{DS(on)}$=f($T_j$), $I_D$=142 A, $V_{GS}$=10 V

**Diagram 10: Typ. gate threshold voltage**



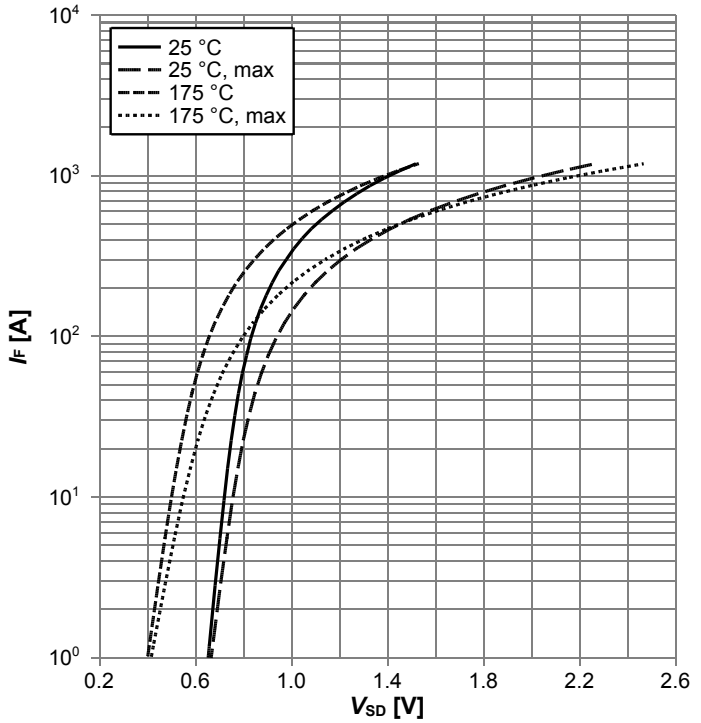

$V_{GS(th}$=f($T_j$), $V_{GS}$=$V_{DS}$; parameter: $I_D$

**Diagram 11: Typ. capacitances**



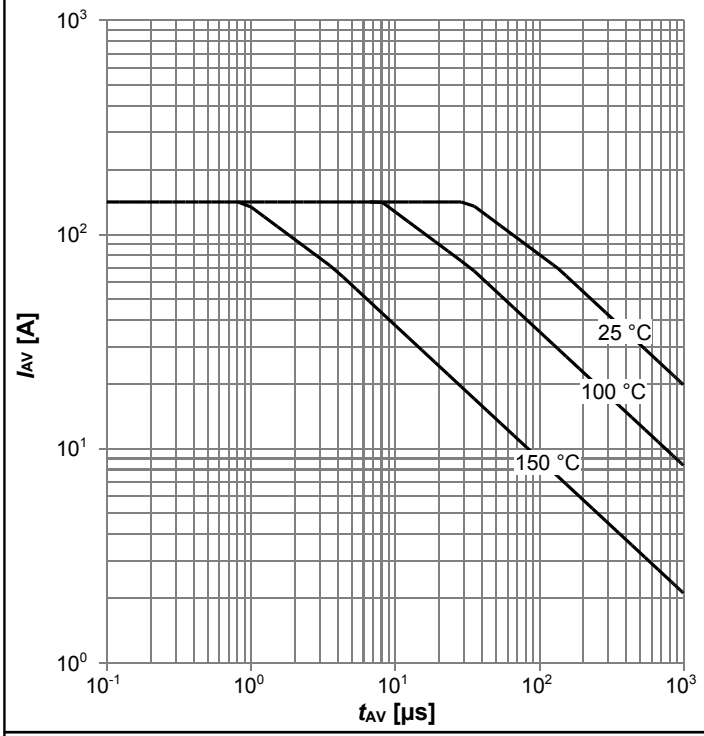

$C$=f($V_{DS}$); $V_{GS}$=0 V; $f$=1 MHz

**Diagram 12: Forward characteristics of reverse diode**



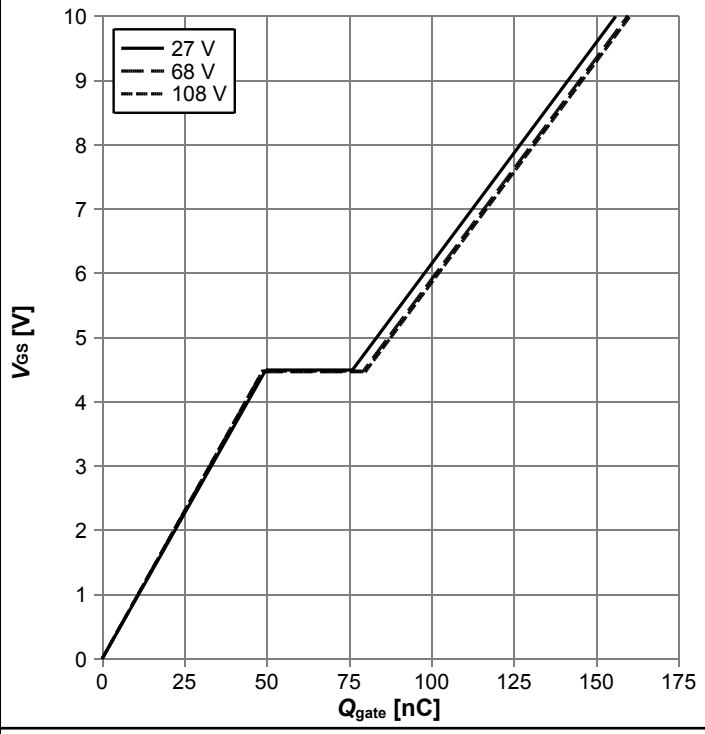

$I_F$=f($V_{SD}$); parameter: $T_j$

**Diagram 13: Avalanche characteristics**



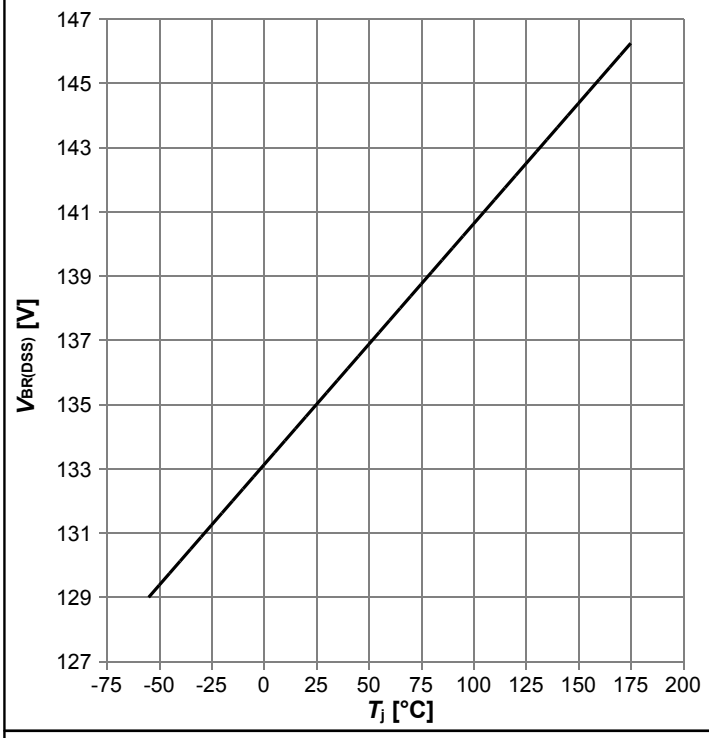

$I_{AS}$=f($t_{AV}$); $R_{GS}$=25 Ω; parameter: $T_{j,start}$

**Diagram 14: Typ. gate charge**



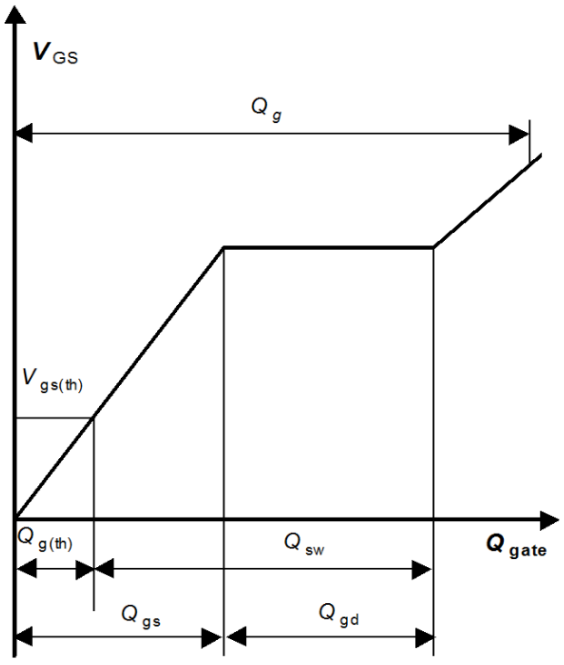

$V_{GS}$=f($Q_{gate}$), $I_D$=71 A pulsed, $T_j$=25 °C; parameter: $V_{DD}$

**Diagram 15: Drain-source breakdown voltage**

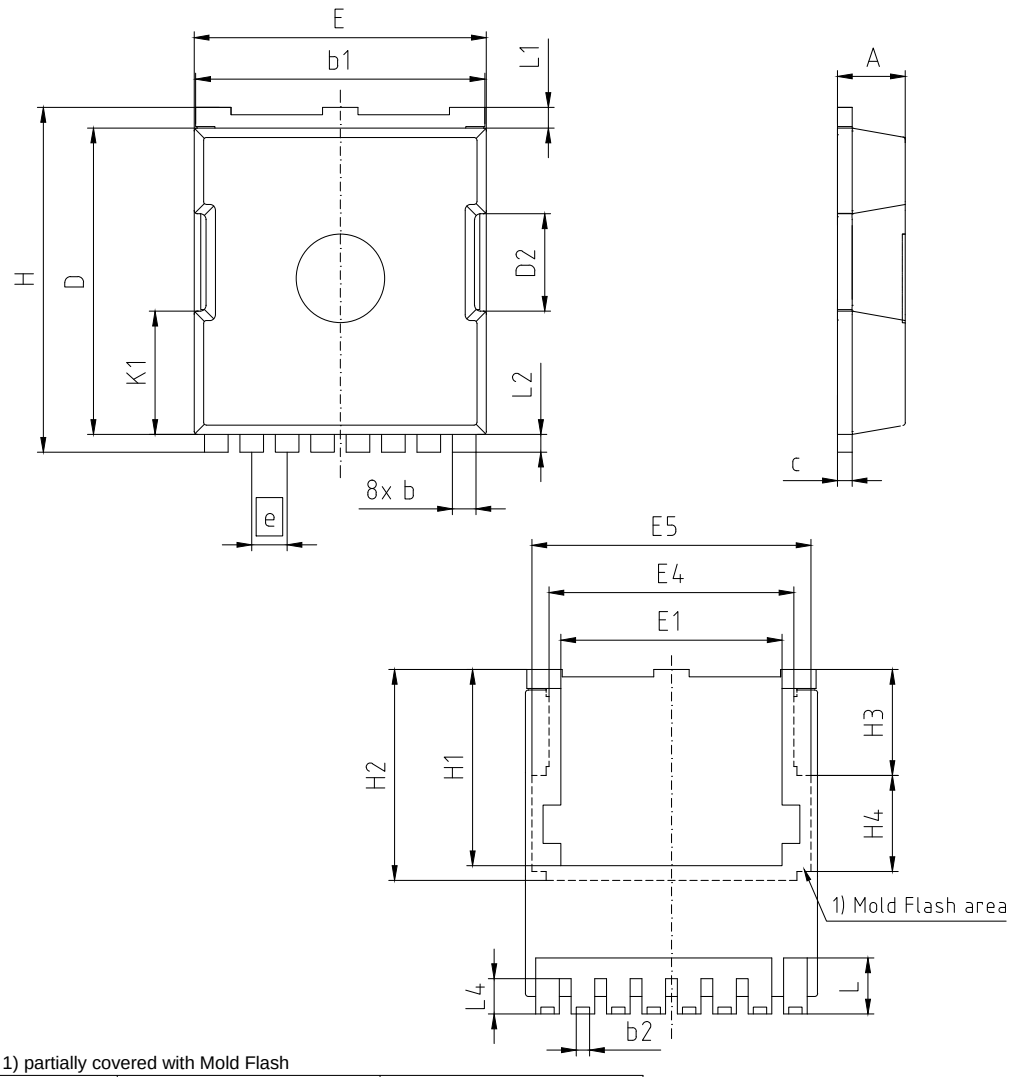



$V_{BR(DSS)}$=f($T_j$); $I_D$=1 mA

**Diagram Gate charge waveforms**



# 5 Package Outlines




1) partially covered with Mold Flash

| DIM | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 2.20 | 2.40 | 0.087 | 0.094 |
| b | 0.70 | 0.90 | 0.028 | 0.035 |
| b1 | 9.70 | 9.90 | 0.382 | 0.390 |
| b2 | 0.42 | 0.50 | 0.017 | 0.020 |
| c | 0.40 | 0.60 | 0.016 | 0.024 |
| D | 10.28 | 10.58 | 0.405 | 0.416 |
| D2 | 3.30 | | 0.130 | |
| E | 9.70 | 10.10 | 0.382 | 0.398 |
| E1 | 7.50 | | 0.295 | |
| E4 | 8.50 | | 0.335 | |
| E5 | 9.46 | | 0.372 | |
| e | 1.20 (BSC) | | 0.047 (BSC) | |
| H | 11.48 | 11.88 | 0.452 | 0.468 |
| H1 | 6.55 | 6.75 | 0.258 | 0.266 |
| H2 | 7.15 | | 0.281 | |
| H3 | 3.59 | | 0.141 | |
| H4 | 3.26 | | 0.128 | |
| N | 8 | | 8 | |
| K1 | 4.18 | | 0.165 | |
| L | 1.60 | 2.10 | 0.063 | 0.083 |
| L1 | 0.70 | | 0.028 | |
| L2 | 0.60 | | 0.024 | |
| L4 | 1.00 | 1.30 | 0.039 | 0.051 |

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Z8B00169619

SCALE
0 2 0 2 4mm

EUROPEAN PROJECTION

ISSUE DATE
20-02-2014

REVISION
02

**Figure 1 Outline PG-HSOF-8, dimensions in mm/inches**

## Revision History

IPT020N13NM6

**Revision: 2023-10-16, Rev. 2.0**

| Previous Revision | | |
|---|---|---|
| Revision | Date | Subjects (major changes since last revision) |
| 2.0 | 2023-10-16 | Release of final version |



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