

MOSFET

OptiMOS™ 6 Power-Transistor, 135 V

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

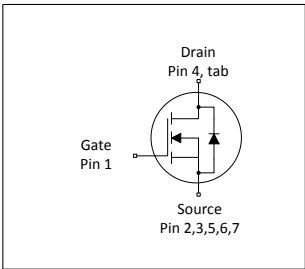
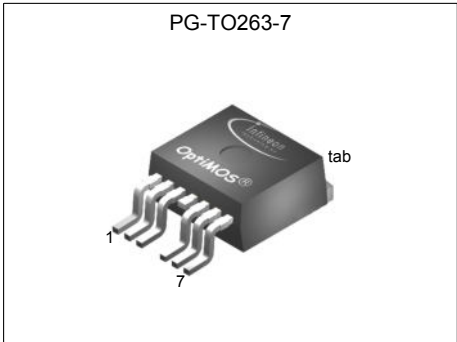
Product validation

Fully qualified according to JEDEC for Industrial Applications

Table 1 Key Performance Parameters

| Parameter          | Value | Unit |
|--------------------|-------|------|
| $V_{DS}$           | 135   | V    |
| $R_{DS(on),max}$   | 3.1   | mΩ   |
| $I_D$              | 207   | A    |
| $Q_{oss}$          | 180   | nC   |
| $Q_G$ (0V...10V)   | 104   | nC   |
| $Q_{rr}$ (500A/μs) | 118   | nC   |

| Type / Ordering Code | Package    | Marking  | Related Links |
|----------------------|------------|----------|---------------|
| IPF031N13NM6         | PG-TO263-7 | 031N13N6 | -             |



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## 1 Maximum ratings

at  $T_A=25\text{ °C}$ , unless otherwise specified

**Table 2 Maximum ratings**

| Parameter                                     | Symbol            | Values |      |                         | Unit | Note / Test Condition                                                                                                                                                                                                 |
|-----------------------------------------------|-------------------|--------|------|-------------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                               |                   | Min.   | Typ. | Max.                    |      |                                                                                                                                                                                                                       |
| Continuous drain current <sup>1)</sup>        | $I_D$             | -      | -    | 207<br>146<br>137<br>23 | A    | $V_{GS}=10\text{ V}$ , $T_C=25\text{ °C}$<br>$V_{GS}=10\text{ V}$ , $T_C=100\text{ °C}$<br>$V_{GS}=8\text{ V}$ , $T_C=100\text{ °C}$<br>$V_{GS}=10\text{ V}$ , $T_A=25\text{ °C}$ ,<br>$R_{THJA}=40\text{ °C/W}^{2)}$ |
| Pulsed drain current <sup>3)</sup>            | $I_{D,pulse}$     | -      | -    | 828                     | A    | $T_C=25\text{ °C}$                                                                                                                                                                                                    |
| Avalanche current, single pulse <sup>4)</sup> | $I_{AS}$          | -      | -    | 90                      | A    | $T_C=25\text{ °C}$                                                                                                                                                                                                    |
| Avalanche energy, single pulse <sup>4)</sup>  | $E_{AS}$          | -      | -    | 435                     | mJ   | $I_D=56\text{ A}$ , $R_{GS}=25\text{ }\Omega$                                                                                                                                                                         |
| Gate source voltage                           | $V_{GS}$          | -20    | -    | 20                      | V    | -                                                                                                                                                                                                                     |
| Power dissipation                             | $P_{tot}$         | -      | -    | 294<br>3.8              | W    | $T_C=25\text{ °C}$<br>$T_A=25\text{ °C}$ , $R_{THJA}=40\text{ °C/W}^{2)}$                                                                                                                                             |
| 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                                      | $R_{thJC}$ | -      | -    | 0.5  | °C/W | -                     |
| Thermal resistance, junction - ambient, 6 cm² cooling area <sup>2)</sup> | $R_{thJA}$ | -      | -    | 40   | °C/W | -                     |
| Thermal resistance, junction - ambient, minimal footprint                | $R_{thJA}$ | -      | -    | 62   | °C/W | -                     |

<sup>1)</sup> 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.

<sup>2)</sup> 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.

<sup>3)</sup> See Diagram 3 for more detailed information

<sup>4)</sup> See Diagram 13 for more detailed information

### 3 Electrical characteristics

at  $T_j=25\text{ °C}$ , 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             | $V_{GS}=0\text{ V}$ , $I_D=1\text{ mA}$                                                                                               |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3.0               | 3.5               | V             | $V_{DS}=V_{GS}$ , $I_D=180\text{ }\mu\text{A}$                                                                                        |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | 1<br>10           | 10<br>100         | $\mu\text{A}$ | $V_{DS}=108\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=25\text{ °C}$<br>$V_{DS}=108\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=125\text{ °C}$ |
| Gate-source leakage current      | $I_{GSS}$     | -      | 10                | 100               | nA            | $V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$                                                                                            |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 2.5<br>2.7<br>2.9 | 3.0<br>3.1<br>3.5 | m $\Omega$    | $V_{GS}=15\text{ V}$ , $I_D=90\text{ A}$<br>$V_{GS}=10\text{ V}$ , $I_D=90\text{ A}$<br>$V_{GS}=8\text{ V}$ , $I_D=45\text{ A}$       |
| Gate resistance <sup>1)</sup>    | $R_G$         | -      | 1.0               | 1.5               | $\Omega$      | -                                                                                                                                     |
| Transconductance <sup>1)</sup>   | $g_{fs}$      | 90     | 180               | -                 | S             | $ V_{DS} \geq 2 I_D /R_{DS(on)max}$ , $I_D=90\text{ A}$                                                                               |

**Table 5 Dynamic characteristics**

| Parameter                                  | Symbol       | Values |      |      | Unit | Note / Test Condition                                                                              |
|--------------------------------------------|--------------|--------|------|------|------|----------------------------------------------------------------------------------------------------|
|                                            |              | Min.   | Typ. | Max. |      |                                                                                                    |
| Input capacitance <sup>1)</sup>            | $C_{iss}$    | -      | 7100 | 9200 | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=68\text{ V}$ , $f=1\text{ MHz}$                                      |
| Output capacitance <sup>1)</sup>           | $C_{oss}$    | -      | 1400 | 1800 | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=68\text{ V}$ , $f=1\text{ MHz}$                                      |
| Reverse transfer capacitance <sup>1)</sup> | $C_{rss}$    | -      | 20   | 35   | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=68\text{ V}$ , $f=1\text{ MHz}$                                      |
| Turn-on delay time                         | $t_{d(on)}$  | -      | 21   | -    | ns   | $V_{DD}=68\text{ V}$ , $V_{GS}=10\text{ V}$ , $I_D=45\text{ A}$ ,<br>$R_{G,ext}=1.6\text{ }\Omega$ |
| Rise time                                  | $t_r$        | -      | 19   | -    | ns   | $V_{DD}=68\text{ V}$ , $V_{GS}=10\text{ V}$ , $I_D=45\text{ A}$ ,<br>$R_{G,ext}=1.6\text{ }\Omega$ |
| Turn-off delay time                        | $t_{d(off)}$ | -      | 35   | -    | ns   | $V_{DD}=68\text{ V}$ , $V_{GS}=10\text{ V}$ , $I_D=45\text{ A}$ ,<br>$R_{G,ext}=1.6\text{ }\Omega$ |
| Fall time                                  | $t_f$        | -      | 15   | -    | ns   | $V_{DD}=68\text{ V}$ , $V_{GS}=10\text{ V}$ , $I_D=45\text{ A}$ ,<br>$R_{G,ext}=1.6\text{ }\Omega$ |

**Table 6 Gate charge characteristics<sup>2)</sup>**

| Parameter                           | Symbol        | Values |      |      | Unit | Note / Test Condition                                                       |
|-------------------------------------|---------------|--------|------|------|------|-----------------------------------------------------------------------------|
|                                     |               | Min.   | Typ. | Max. |      |                                                                             |
| Gate to source charge <sup>1)</sup> | $Q_{gs}$      | -      | 32   | 42   | nC   | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Gate charge at threshold            | $Q_{g(th)}$   | -      | 21   | -    | nC   | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Gate to drain charge <sup>1)</sup>  | $Q_{gd}$      | -      | 20   | 30   | nC   | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Switching charge                    | $Q_{sw}$      | -      | 31   | -    | nC   | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Gate charge total <sup>1)</sup>     | $Q_g$         | -      | 104  | 135  | nC   | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Gate plateau voltage                | $V_{plateau}$ | -      | 4.5  | -    | V    | $V_{DD}=68\text{ V}$ , $I_D=45\text{ A}$ , $V_{GS}=0\text{ to }10\text{ V}$ |
| Gate charge total, sync. FET        | $Q_{g(sync)}$ | -      | 95   | -    | nC   | $V_{DS}=0.1\text{ V}$ , $V_{GS}=0\text{ to }10\text{ V}$                    |
| Output charge <sup>1)</sup>         | $Q_{oss}$     | -      | 180  | 234  | nC   | $V_{DS}=68\text{ V}$ , $V_{GS}=0\text{ V}$                                  |

<sup>1)</sup> Defined by design. Not subject to production test.

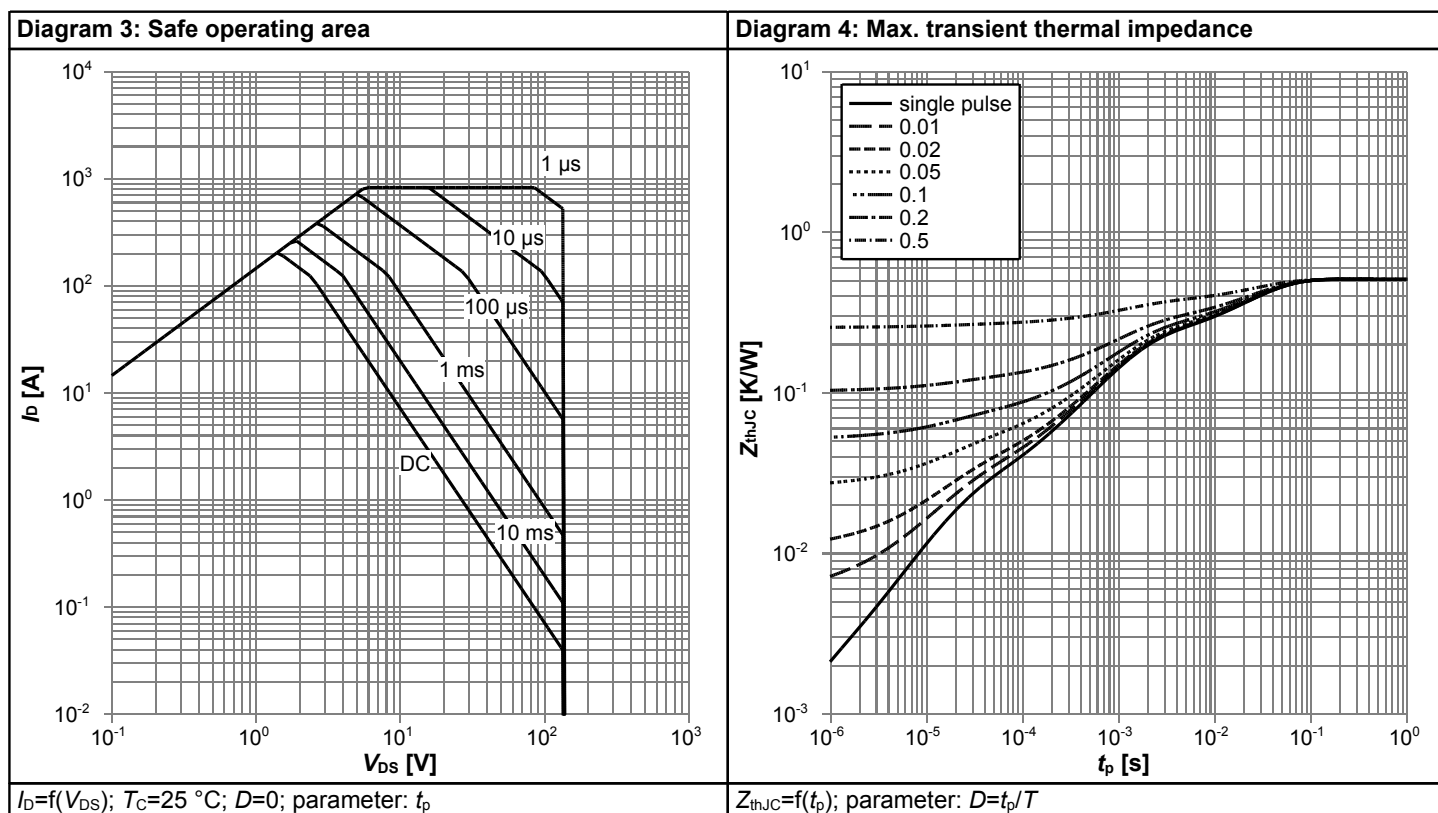
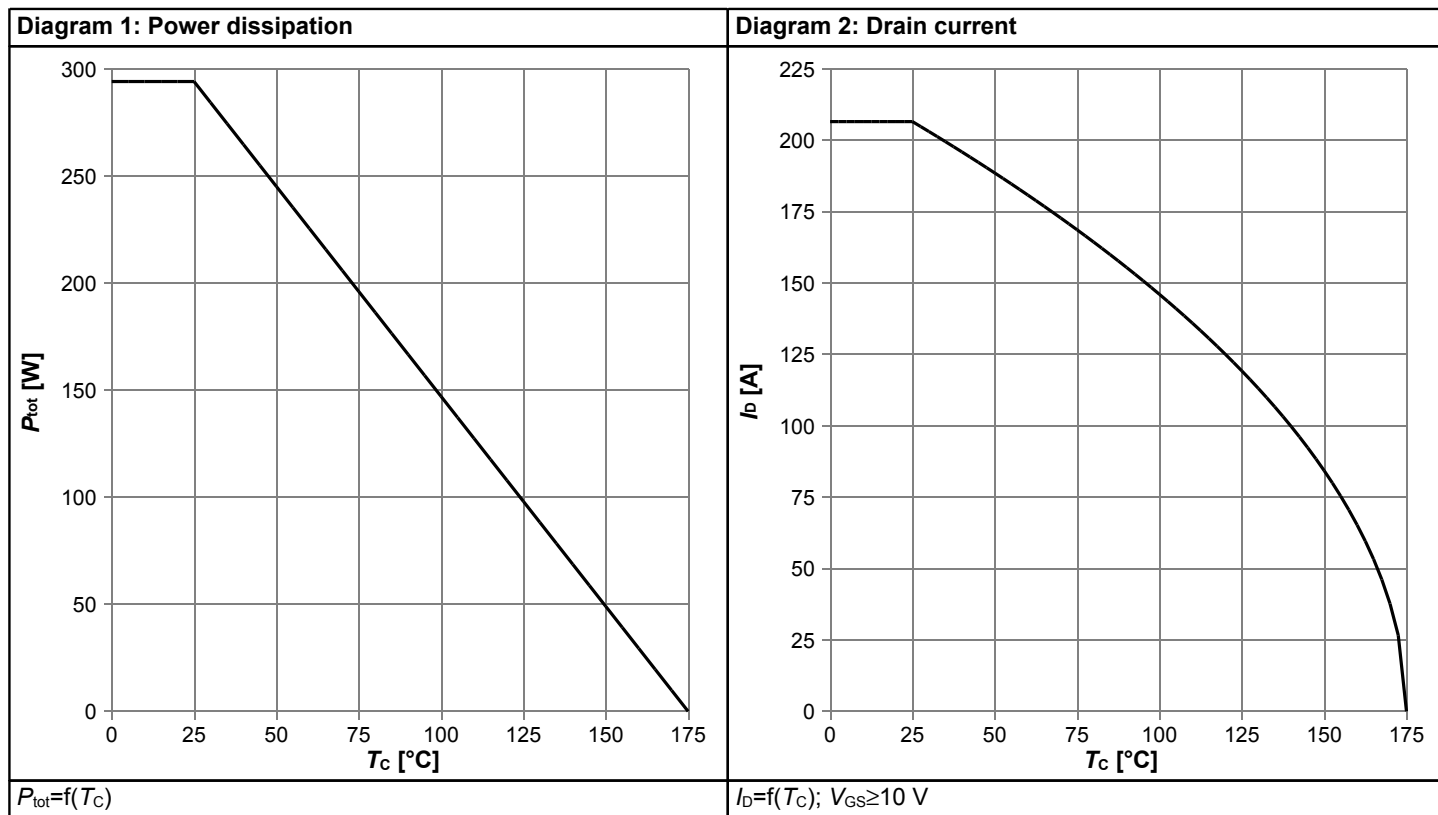
<sup>2)</sup> See "Gate charge waveforms" for parameter definition

**Table 7 Reverse diode**

| Parameter                             | Symbol        | Values |      |      | Unit | Note / Test Condition                                                      |
|---------------------------------------|---------------|--------|------|------|------|----------------------------------------------------------------------------|
|                                       |               | Min.   | Typ. | Max. |      |                                                                            |
| Diode continuous forward current      | $I_S$         | -      | -    | 207  | A    | $T_C=25\text{ °C}$                                                         |
| Diode pulse current                   | $I_{S,pulse}$ | -      | -    | 828  | A    | $T_C=25\text{ °C}$                                                         |
| Diode forward voltage                 | $V_{SD}$      | -      | 0.87 | 1    | V    | $V_{GS}=0\text{ V}$ , $I_F=90\text{ A}$ , $T_j=25\text{ °C}$               |
| Reverse recovery time <sup>1)</sup>   | $t_{rr}$      | -      | 32   | 64   | ns   | $V_R=68\text{ V}$ , $I_F=45\text{ A}$ , $di_F/dt=500\text{ A/}\mu\text{s}$ |
| Reverse recovery charge <sup>1)</sup> | $Q_{rr}$      | -      | 118  | 236  | nC   | $V_R=68\text{ V}$ , $I_F=45\text{ A}$ , $di_F/dt=500\text{ A/}\mu\text{s}$ |

<sup>1)</sup> Defined by design. Not subject to production test.

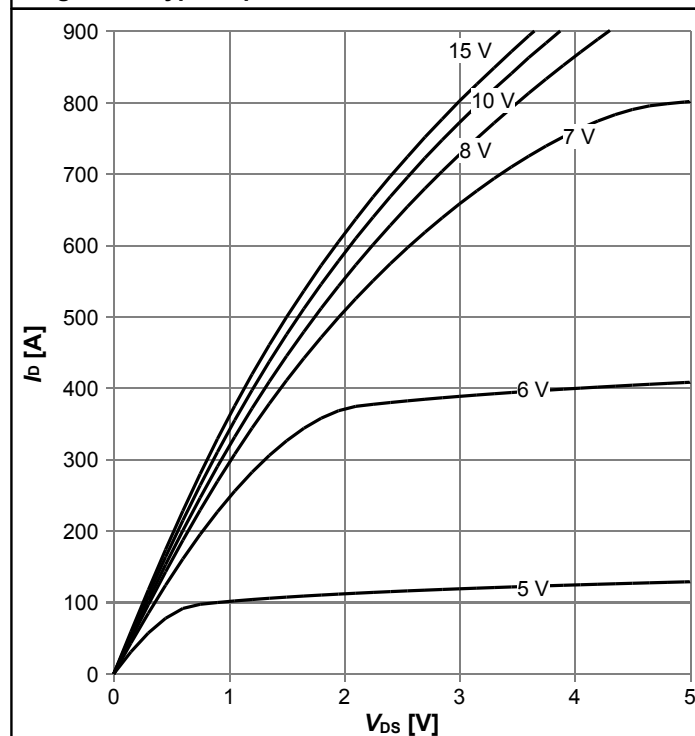
## 4 Electrical characteristics diagrams



# OptiMOS™ 6 Power-Transistor, 135 V

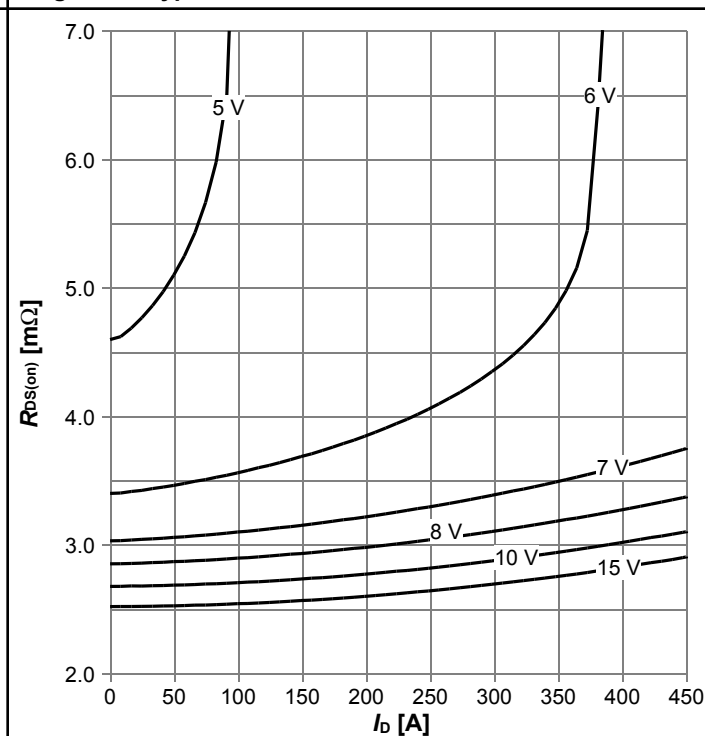
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Diagram 5: Typ. output characteristics



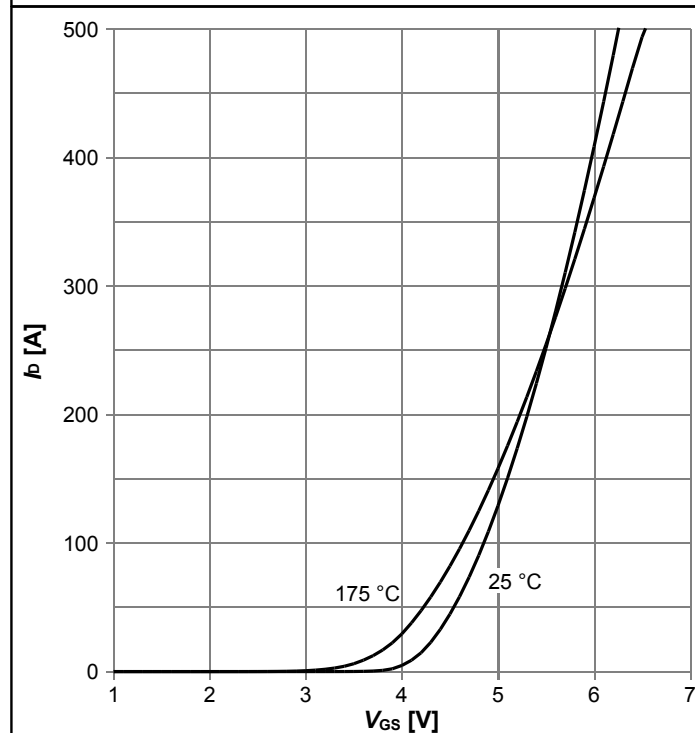
$I_D = f(V_{DS})$ ,  $T_j = 25^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 6: Typ. drain-source on resistance



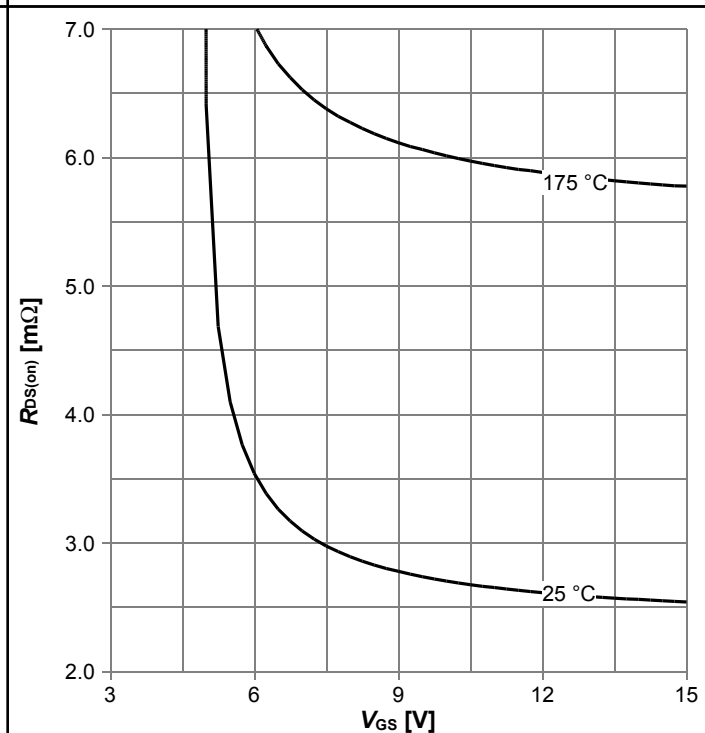
$R_{DS(on)} = f(I_D)$ ,  $T_j = 25^\circ\text{C}$ ; parameter:  $V_{GS}$

Diagram 7: Typ. transfer characteristics



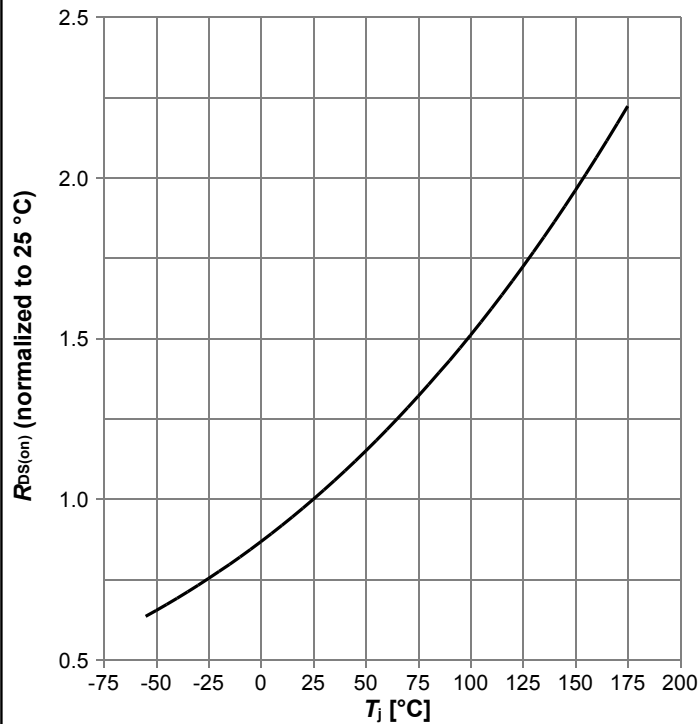
$I_D = f(V_{GS})$ ,  $|V_{DS}| > 2|I_D|R_{DS(on)\text{max}}$ ; parameter:  $T_j$

Diagram 8: Typ. drain-source on resistance



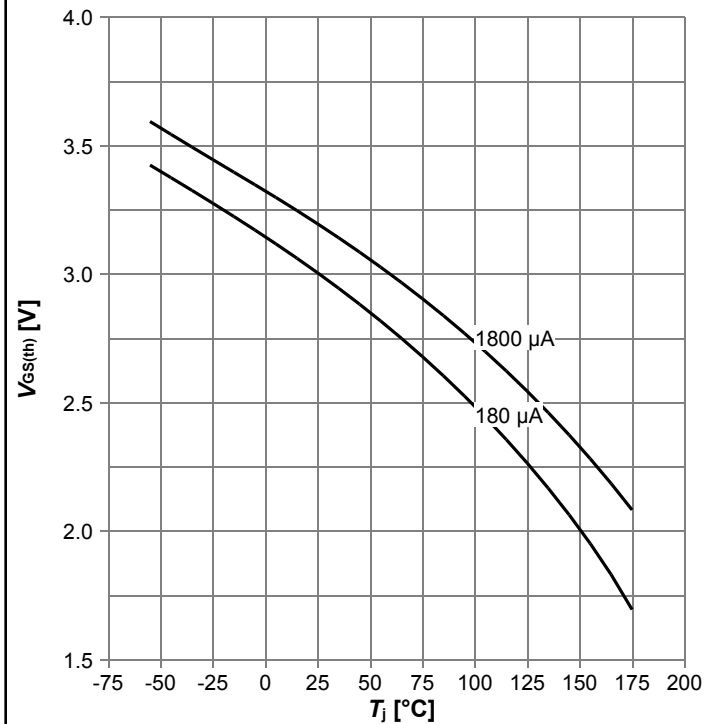
$R_{DS(on)} = f(V_{GS})$ ,  $I_D = 90\text{ A}$ ; parameter:  $T_j$

Diagram 9: Normalized drain-source on resistance



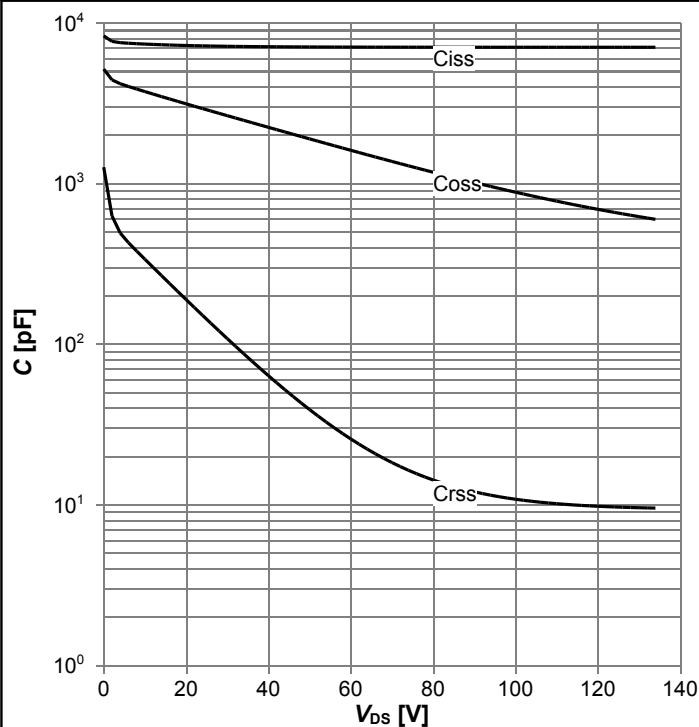
$R_{DS(on)} = f(T_j)$ ,  $I_D = 90$  A,  $V_{GS} = 10$  V

Diagram 10: Typ. gate threshold voltage



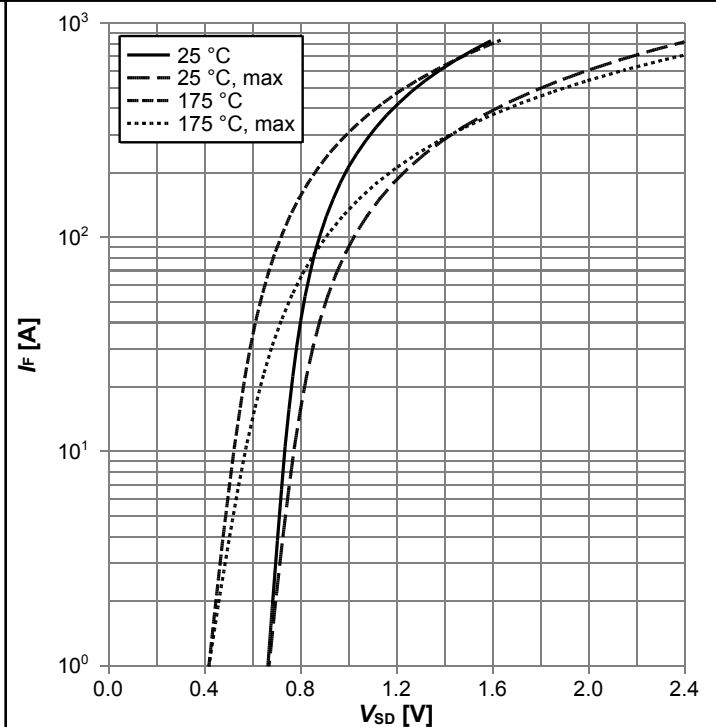
$V_{GS(th)} = f(T_j)$ ,  $V_{GS} = V_{DS}$ ; parameter:  $I_D$

Diagram 11: Typ. capacitances



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

Diagram 12: Forward characteristics of reverse diode



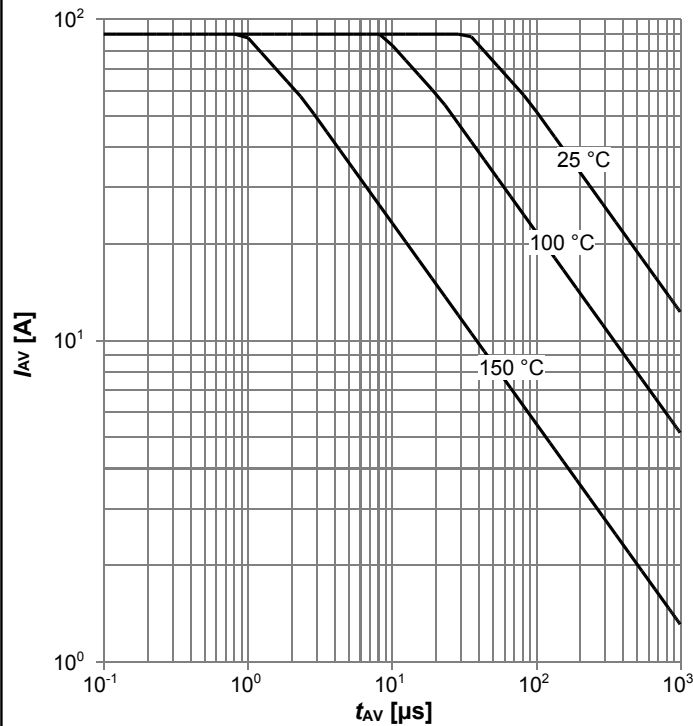
$I_F = f(V_{SD})$ ; parameter:  $T_j$



# OptiMOS™ 6 Power-Transistor, 135 V

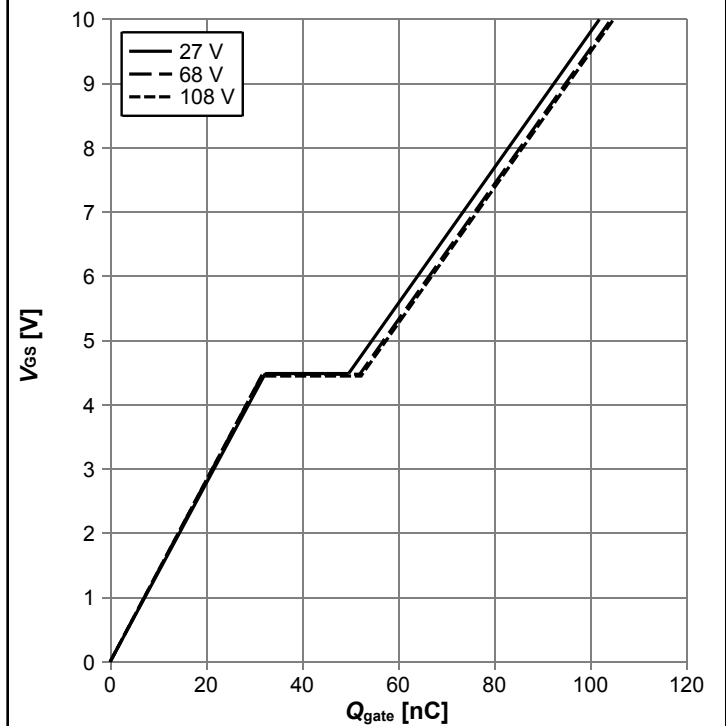
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Diagram 13: Avalanche characteristics



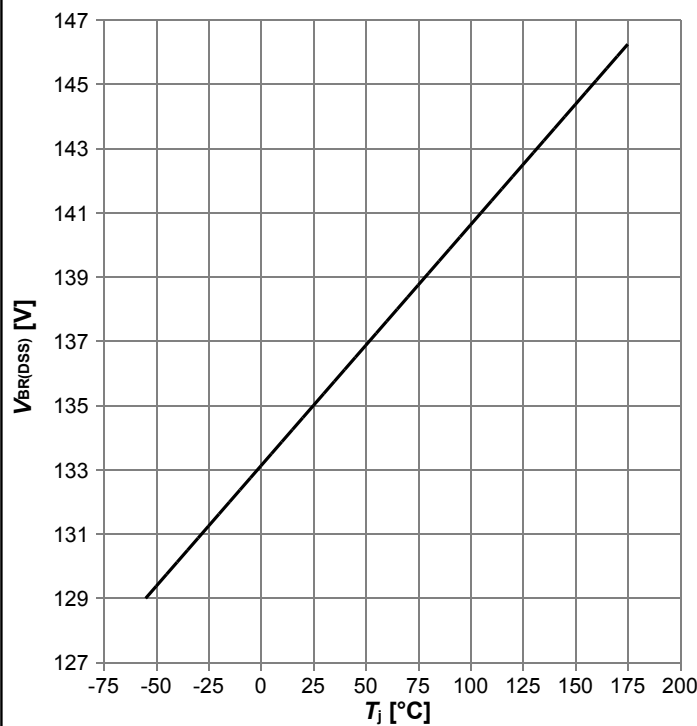
$I_{AS}=f(t_{AV})$ ;  $R_{GS}=25\ \Omega$ ; parameter:  $T_{j,start}$

Diagram 14: Typ. gate charge



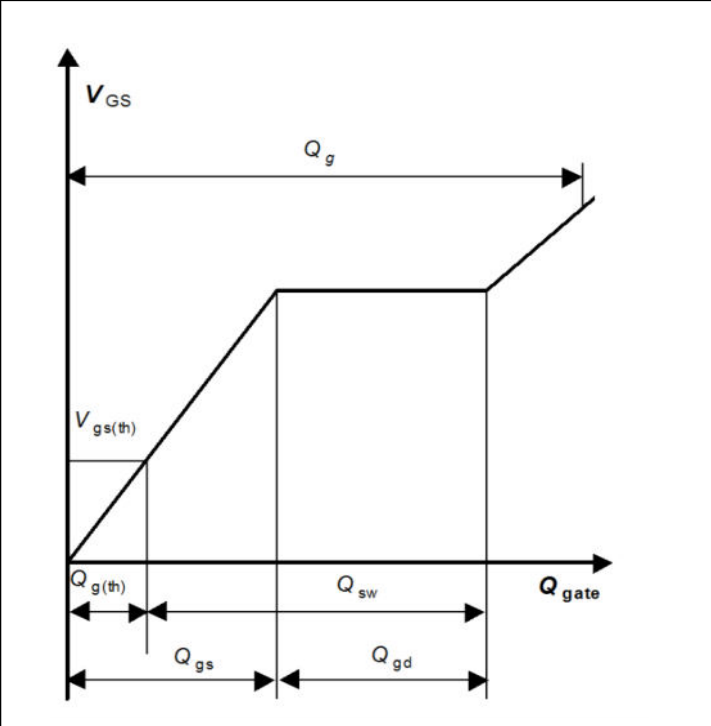
$V_{GS}=f(Q_{gate})$ ,  $I_D=45\text{ A}$  pulsed,  $T_j=25\text{ °C}$ ; parameter:  $V_{DD}$

Diagram 15: Drain-source breakdown voltage

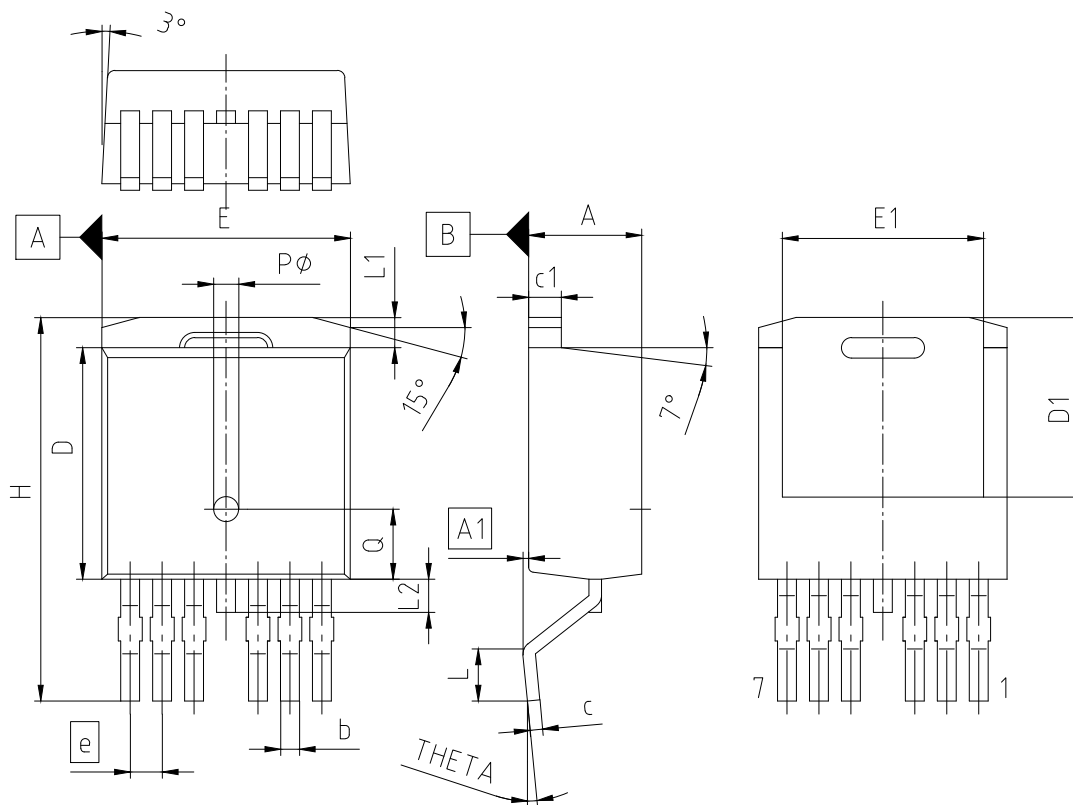


$V_{BR(DSS)}=f(T_j)$ ;  $I_D=1\text{ mA}$

Diagram Gate charge waveforms



## 5 Package Outlines



| PACKAGE - GROUP<br>NUMBER: <b>PG-TO263-7-U02</b> |             |       |
|--------------------------------------------------|-------------|-------|
| DIMENSIONS                                       | MILLIMETERS |       |
|                                                  | MIN.        | MAX.  |
| <b>A</b>                                         | 4.30        | 4.70  |
| <b>A1</b>                                        | 0.00        | 0.25  |
| <b>b</b>                                         | 0.65        | 0.85  |
| <b>c</b>                                         | 0.45        | 0.60  |
| <b>c1</b>                                        | 1.25        | 1.40  |
| <b>D</b>                                         | 9.00        | 9.40  |
| <b>D1</b>                                        | 6.86        | 7.42  |
| <b>E</b>                                         | 9.68        | 10.08 |
| <b>E1</b>                                        | 7.70        | 8.30  |
| <b>e</b>                                         | 1.27        |       |
| <b>N</b>                                         | 7           |       |
| <b>H</b>                                         | 14.61       | 15.88 |
| <b>L</b>                                         | 1.78        | 2.79  |
| <b>L1</b>                                        | 0.00        | 1.60  |
| <b>L2</b>                                        | 0.00        | 1.78  |
| <b>THETA</b>                                     | 0° - 8°     |       |
| <b>PØ</b>                                        | 0.90        | 1.10  |
| <b>Q</b>                                         | 2.78        |       |

Figure 1 Outline PG-TO263-7, dimensions in mm

## Revision History

IPF031N13NM6

**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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