

Cool MOS™ Power Transistor

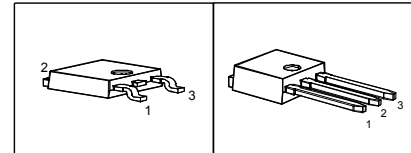
Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC⁰⁾ for target applications

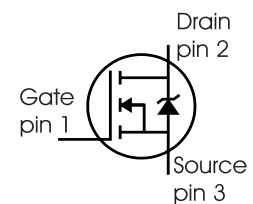
| | | |
|--------------|------|----------|
| V_{DS} | 600 | V |
| $R_{DS(on)}$ | 0.95 | Ω |
| I_D | 4.5 | A |

PG-TO252

PG-TO251



| Type | Package | Ordering Code | Marking |
|------------|----------|---------------|---------|
| SPU04N60S5 | PG-TO251 | Q67040-S4228 | 04N60S5 |
| SPD04N60S5 | PG-TO252 | Q67040-S4202 | 04N60S5 |



Maximum Ratings

| Parameter | Symbol | Value | Unit |
|---|---------------------|-------------|------------------|
| Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$ | I_D | 4.5 2.8 | A |
| Pulsed drain current, t_p limited by T_{jmax} | $I_{D\text{ puls}}$ | 9 | |
| Avalanche energy, single pulse $I_D = 3.4\text{ A}$, $V_{DD} = 50\text{ V}$ | E_{AS} | 130 | mJ |
| Avalanche energy, repetitive t_{AR} limited by T_{jmax} ¹ $I_D = 4.5\text{ A}$, $V_{DD} = 50\text{ V}$ | E_{AR} | 0.4 | |
| Avalanche current, repetitive t_{AR} limited by T_{jmax} | I_{AR} | 4.5 | A |
| Gate source voltage | V_{GS} | ± 20 | V |
| Gate source voltage AC ($f > 1\text{ Hz}$) | V_{GS} | ± 30 | |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$ | P_{tot} | 50 | W |
| Operating and storage temperature | T_j, T_{stg} | -55... +150 | $^\circ\text{C}$ |

Maximum Ratings

| Parameter | Symbol | Value | Unit |
|--|---------|-------|------|
| Drain Source voltage slope $V_{DS} = 480\text{ V}, I_D = 4.5\text{ A}, T_j = 125\text{ °C}$ | dv/dt | 20 | V/ns |

Thermal Characteristics

| Parameter | Symbol | Values | | | Unit |
|---|------------|--------|------|------|------|
| | | min. | typ. | max. | |
| Thermal resistance, junction - case | R_{thJC} | - | - | 2.5 | K/W |
| Thermal resistance, junction - ambient, leaded | R_{thJA} | - | - | 62 | |
| SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ²⁾ | R_{thJA} | - | - | 62 | |
| Soldering temperature, *) 1.6 mm (0.063 in.) from case for 10s | T_{sold} | - | - | 260 | °C |

Electrical Characteristics, at $T_j=25\text{ °C}$ unless otherwise specified

| Parameter | Symbol | Conditions | Values | | | Unit |
|--|---------------|---|--------|------|------|---------------|
| | | | min. | typ. | max. | |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}, I_D=0.25\text{mA}$ | 600 | - | - | V |
| Drain-Source avalanche breakdown voltage | $V_{(BR)DS}$ | $V_{GS}=0\text{V}, I_D=4.5\text{A}$ | - | 700 | - | |
| Gate threshold voltage | $V_{GS(th)}$ | $I_D=200\mu\text{A}, V_{GS}=V_{DS}$ | 3.5 | 4.5 | 5.5 | |
| Zero gate voltage drain current | I_{DSS} | $V_{DS}=600\text{V}, V_{GS}=0\text{V},$ $T_j=25\text{ °C},$ $T_j=150\text{ °C}$ | - | 0.5 | 1 | μA |
| | | | - | - | 50 | |
| Gate-source leakage current | I_{GSS} | $V_{GS}=20\text{V}, V_{DS}=0\text{V}$ | - | - | 100 | nA |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}=10\text{V}, I_D=2.8\text{A},$ $T_j=25\text{ °C}$ $T_j=150\text{ °C}$ | - | 0.85 | 0.95 | Ω |
| | | | - | 2.3 | - | |
| Gate input resistance | R_G | $f=1\text{MHz}, \text{open Drain}$ | - | 20 | - | |

*) TO252: reflow soldering, MSL3; TO251: wavesoldering

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

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|--|--------|------|------|------|
| | | | min. | typ. | max. | |
| Characteristics | | | | | | |
| Transconductance | g_{fs} | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8\text{A}$ | - | 2.5 | - | S |
| Input capacitance | C_{iss} | $V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1\text{MHz}$ | - | 580 | - | pF |
| Output capacitance | C_{oss} | | - | 220 | - | |
| Reverse transfer capacitance | C_{rss} | | - | 7 | - | |
| Effective output capacitance, ³⁾ energy related | $C_{o(er)}$ | $V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V to } 480\text{V}$ | - | 20 | - | pF |
| Effective output capacitance, ⁴⁾ time related | $C_{o(tr)}$ | | - | 35 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 350\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 4.5\text{A}$, $R_G = 18\Omega$ | - | 55 | - | ns |
| Rise time | t_r | $V_{DD} = 350\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 4.5\text{A}$, $R_G = 18$ | - | 30 | - | |
| Turn-off delay time | $t_{d(off)}$ | $V_{DD} = 350\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 4.5\text{A}$, $R_G = 18\Omega$ | - | 60 | 90 | |
| Fall time | t_f | | - | 15 | 22.5 | |

Gate Charge Characteristics

| | | | | | | |
|-----------------------|-----------------|--|---|------|------|----|
| Gate to source charge | Q_{gs} | $V_{DD} = 350\text{V}$, $I_D = 4.5\text{A}$ | - | 4.5 | - | nC |
| Gate to drain charge | Q_{gd} | | - | 11 | - | |
| Gate charge total | Q_g | $V_{DD} = 350\text{V}$, $I_D = 4.5\text{A}$, $V_{GS} = 0\text{ to } 10\text{V}$ | - | 17.6 | 22.9 | |
| Gate plateau voltage | $V_{(plateau)}$ | $V_{DD} = 350\text{V}$, $I_D = 4.5\text{A}$ | - | 8 | - | V |

⁰J-STD20 and JESD22

¹Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

²Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

³ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

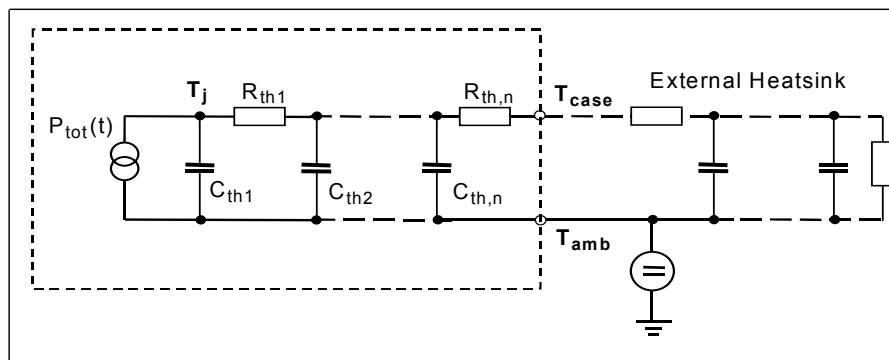
⁴ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

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

| Parameter | Symbol | Conditions | Values | | | Unit |
|--|----------|-----------------------------------|--------|------|------|---------------|
| | | | min. | typ. | max. | |
| Inverse diode continuous forward current | I_S | $T_C=25^\circ\text{C}$ | - | - | 4.5 | A |
| Inverse diode direct current, pulsed | I_{SM} | | - | - | 9 | |
| Inverse diode forward voltage | V_{SD} | $V_{GS}=0\text{V}, I_F=I_S$ | - | 1 | 1.2 | V |
| Reverse recovery time | t_{rr} | $V_R=350\text{V}, I_F=I_S$ | - | 900 | 1530 | ns |
| Reverse recovery charge | Q_{rr} | $di_F/dt=100\text{A}/\mu\text{s}$ | - | 3.2 | - | μC |

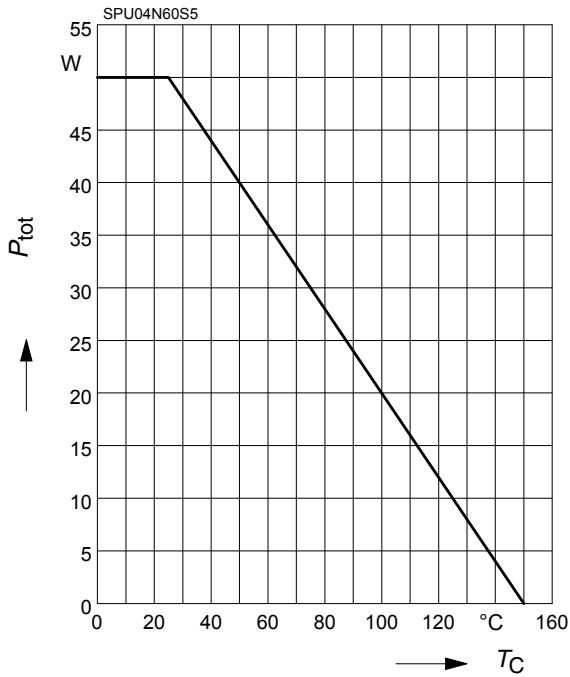
Typical Transient Thermal Characteristics

| Symbol | Value | Unit | Symbol | Value | Unit |
|--------------------|-------|------|---------------------|------------|------|
| | typ. | | | typ. | |
| Thermal resistance | | | Thermal capacitance | | |
| R_{th1} | 0.039 | K/W | C_{th1} | 0.00007347 | Ws/K |
| R_{th2} | 0.074 | | C_{th2} | 0.0002831 | |
| R_{th3} | 0.132 | | C_{th3} | 0.0004062 | |
| R_{th4} | 0.555 | | C_{th4} | 0.001215 | |
| R_{th5} | 0.529 | | C_{th5} | 0.00276 | |
| R_{th6} | 0.169 | | C_{th6} | 0.029 | |



1 Power dissipation

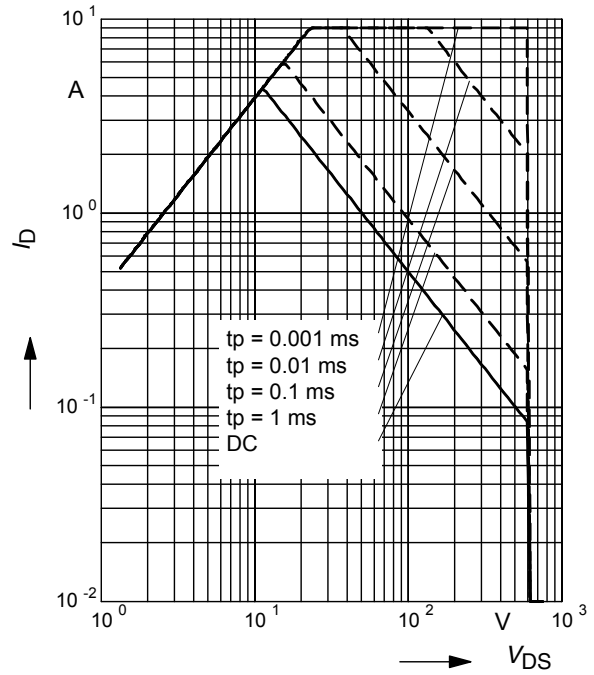
$P_{tot} = f(T_C)$



2 Safe operating area

$I_D = f(V_{DS})$

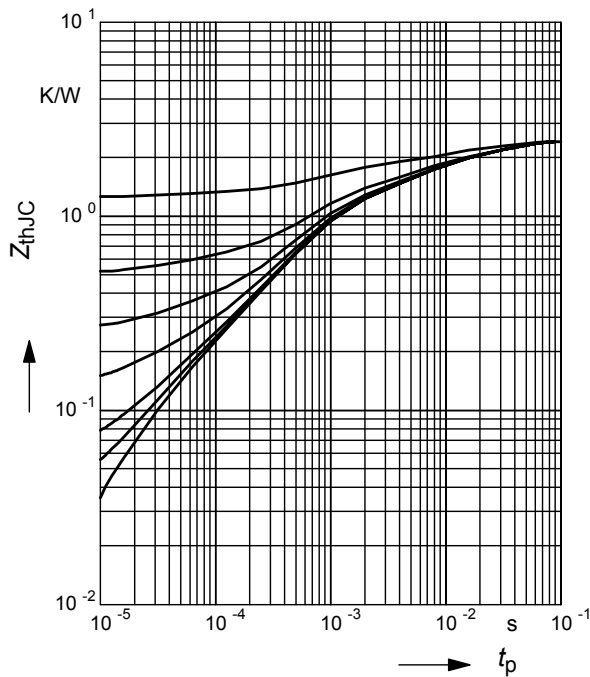
parameter : $D = 0, T_C = 25^\circ\text{C}$



3 Transient thermal impedance

$Z_{thJC} = f(t_p)$

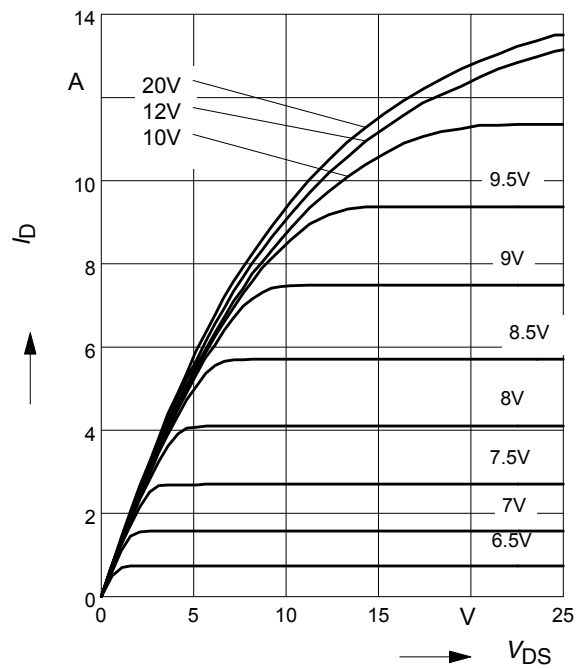
parameter: $D = t_p/T$



4 Typ. output characteristic

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

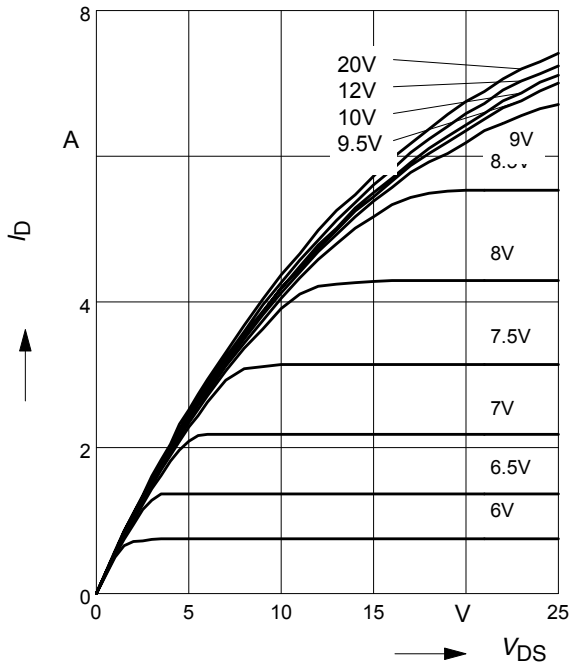
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



5 Typ. output characteristic

$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$

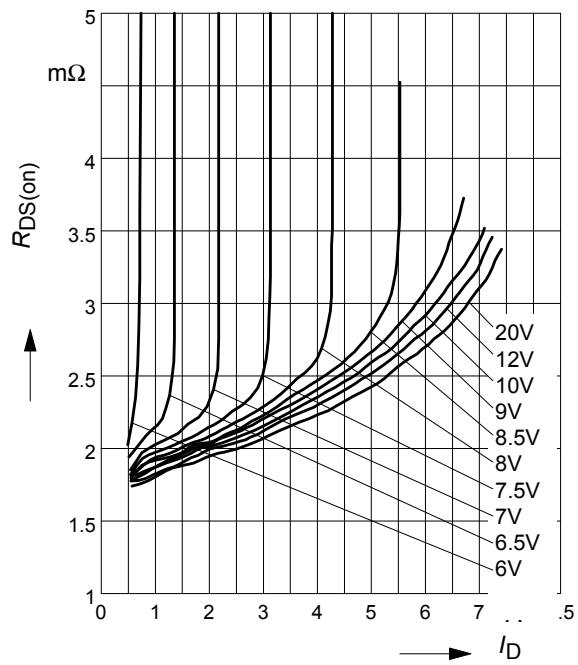
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



6 Typ. drain-source on resistance

$R_{DS(on)} = f(I_D)$

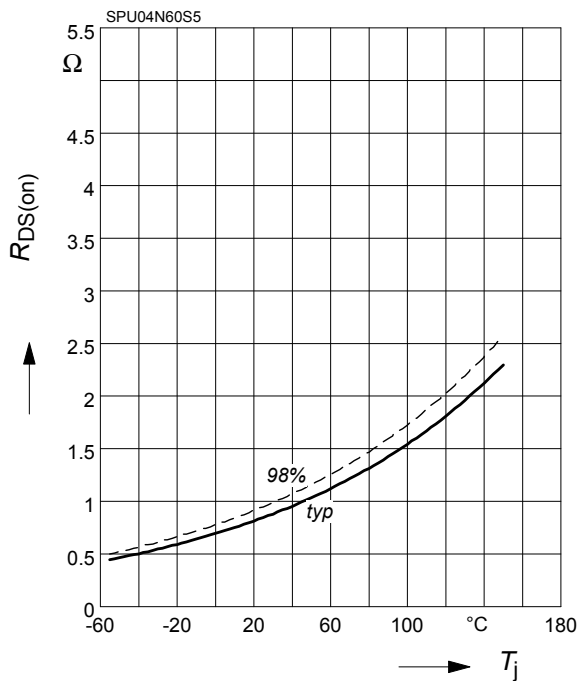
parameter: $T_j = 150^\circ\text{C}, V_{GS}$



7 Drain-source on-state resistance

$R_{DS(on)} = f(T_j)$

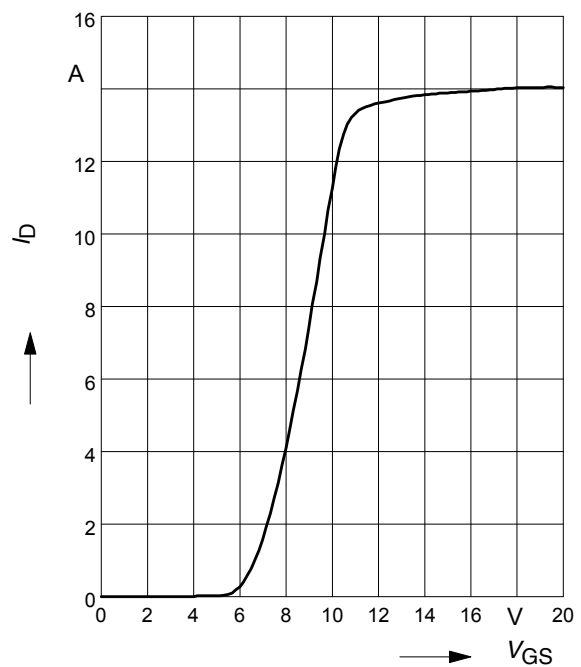
parameter: $I_D = 2.8 \text{ A}, V_{GS} = 10 \text{ V}$



8 Typ. transfer characteristics

$I_D = f(V_{GS}); V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$

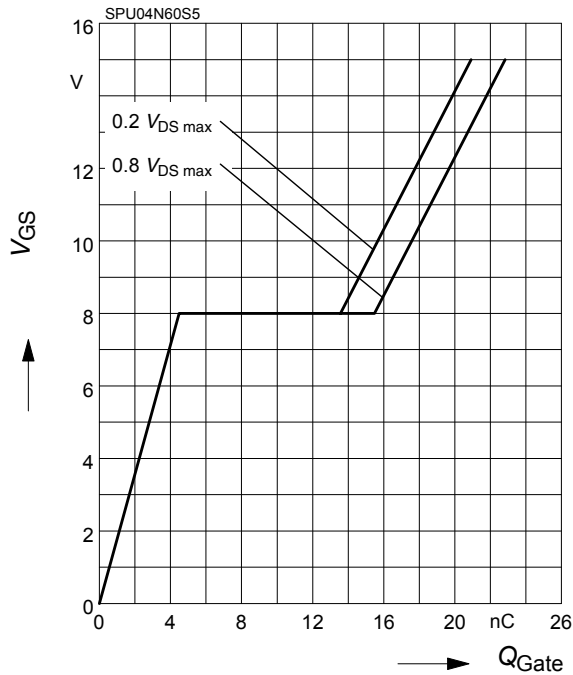
parameter: $t_p = 10 \mu\text{s}$



9 Typ. gate charge

$$V_{GS} = f(Q_{Gate})$$

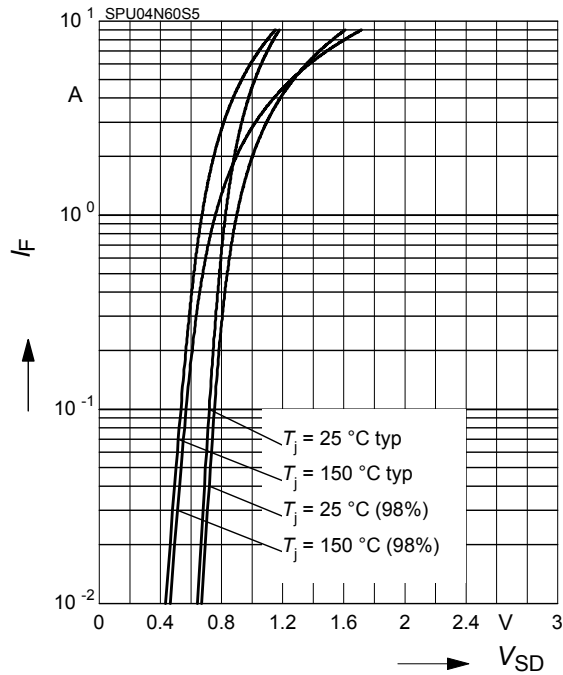
parameter: $I_D = 4.5$ A pulsed



10 Forward characteristics of body diode

$$I_F = f(V_{SD})$$

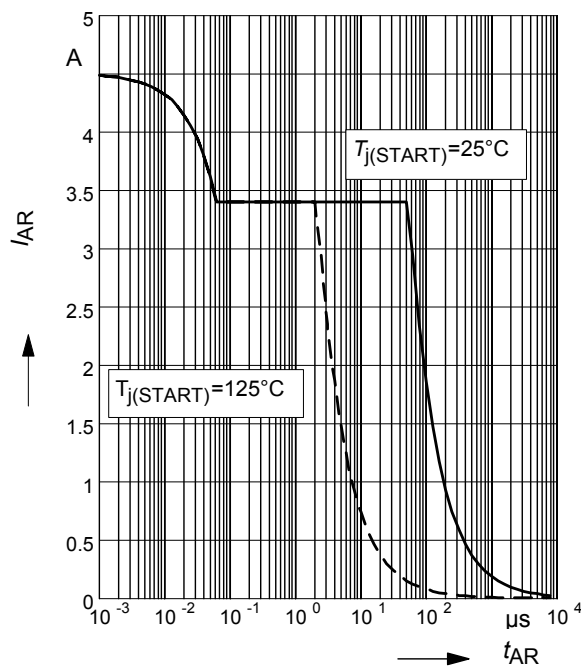
parameter: $T_j, t_p = 10$ μ s



11 Avalanche SOA

$$I_{AR} = f(t_{AR})$$

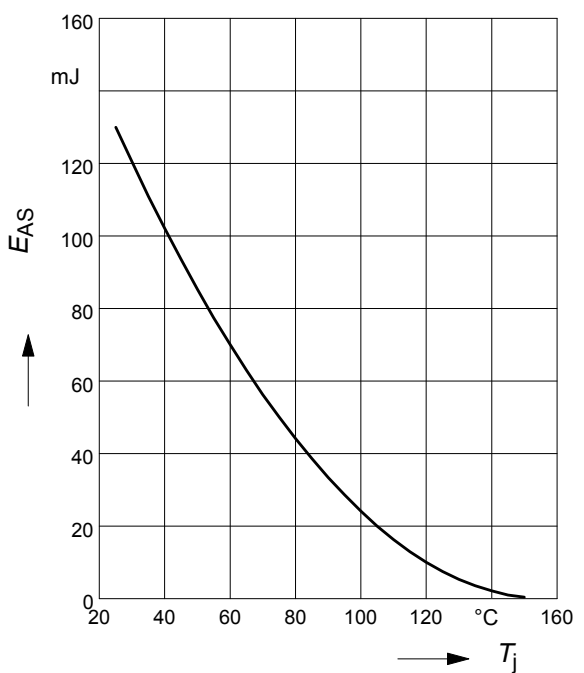
par.: $T_j \leq 150$ °C



12 Avalanche energy

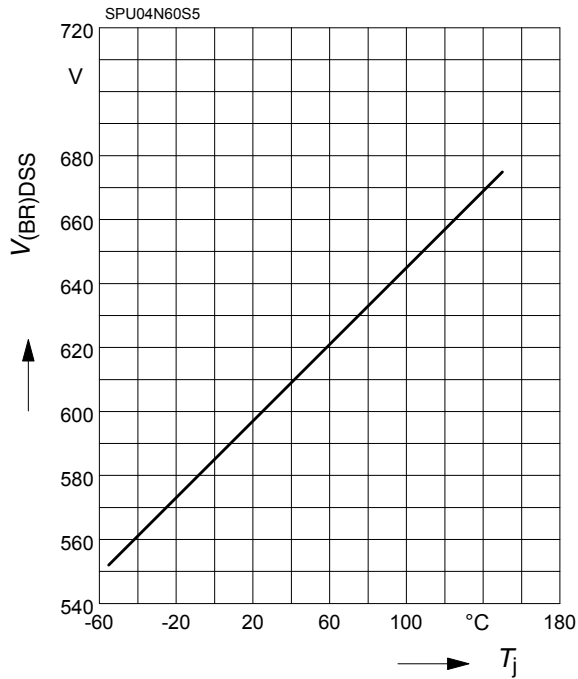
$$E_{AS} = f(T_j)$$

par.: $I_D = 3.4$ A, $V_{DD} = 50$ V



13 Drain-source breakdown voltage

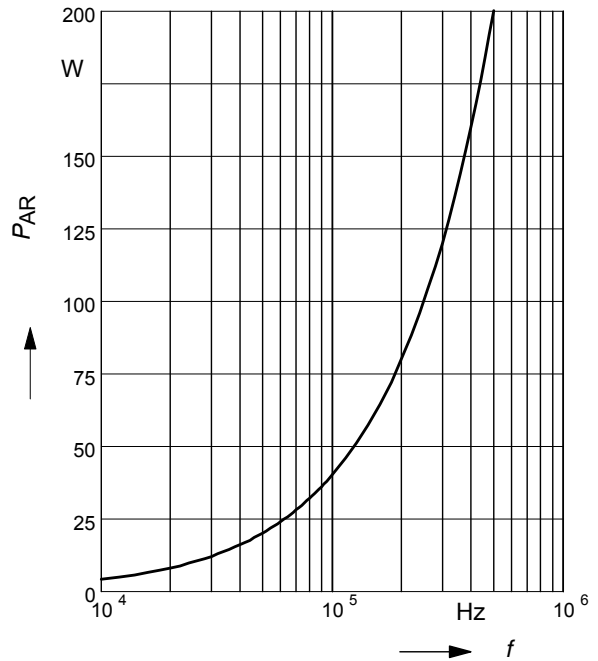
$$V_{(BR)DSS} = f(T_j)$$



14 Avalanche power losses

$$P_{AR} = f(f)$$

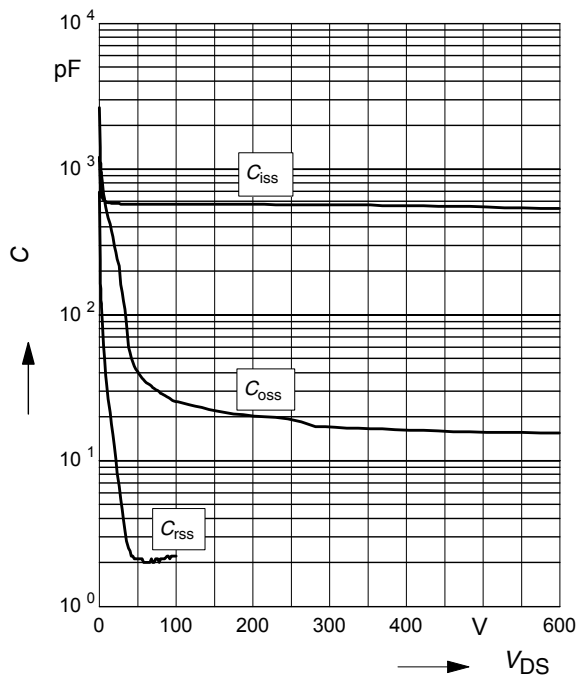
parameter: $E_{AR}=0.4\text{mJ}$



15 Typ. capacitances

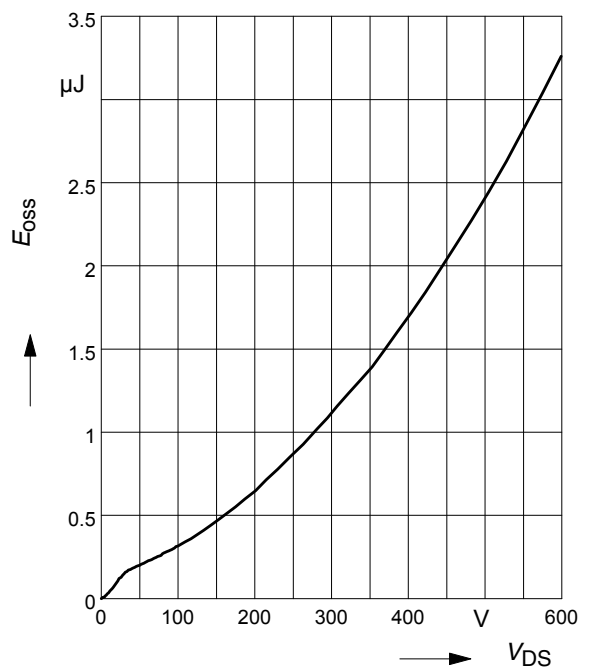
$$C = f(V_{DS})$$

parameter: $V_{GS}=0\text{V}$, $f=1\text{ MHz}$

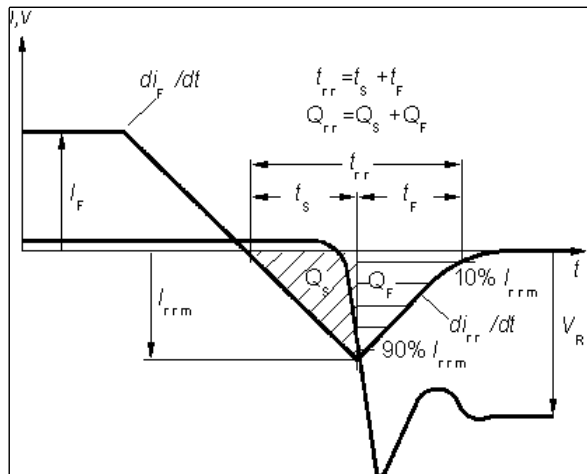


16 Typ. C_{OSS} stored energy

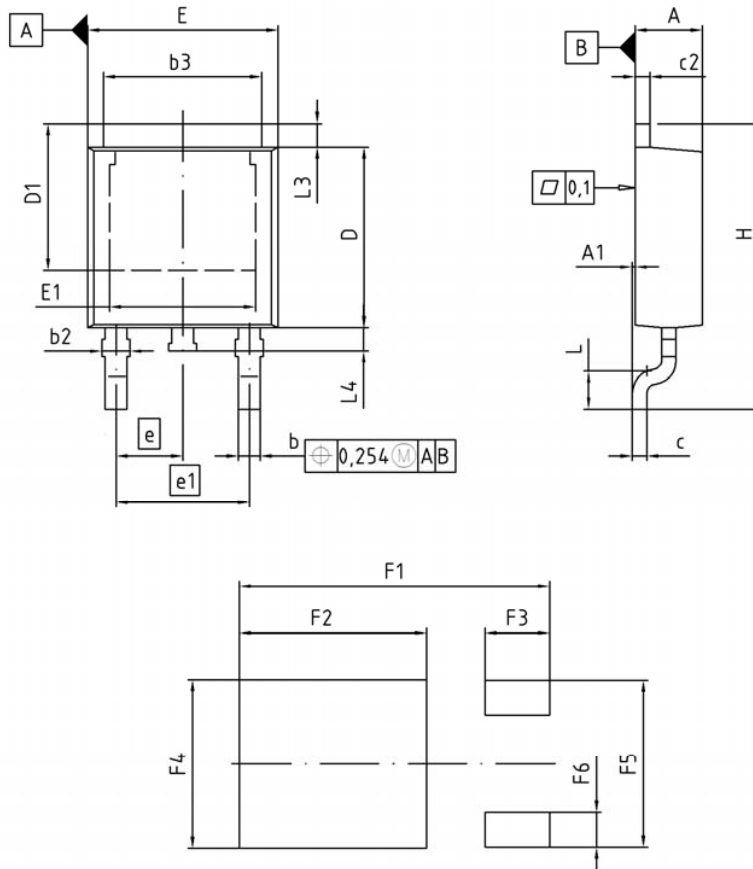
$$E_{OSS} = f(V_{DS})$$



Definition of diodes switching characteristics



PG-TO252-3-1, PG-TO252-3-11, PG-TO252-3-21 (D-PAK)



| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|-------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.16 | 2.41 | 0.085 | 0.095 |
| A1 | 0.00 | 0.15 | 0.000 | 0.006 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b3 | 5.00 | 5.50 | 0.197 | 0.217 |
| c | 0.46 | 0.60 | 0.018 | 0.024 |
| c2 | 0.46 | 0.98 | 0.018 | 0.039 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.02 | 5.84 | 0.198 | 0.230 |
| E | 6.40 | 6.73 | 0.252 | 0.265 |
| E1 | 4.70 | 5.21 | 0.185 | 0.205 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| H | 9.40 | 10.48 | 0.370 | 0.413 |
| L | 1.18 | 1.70 | 0.046 | 0.067 |
| L3 | 0.90 | 1.25 | 0.035 | 0.049 |
| L4 | 0.51 | 1.00 | 0.020 | 0.039 |
| F1 | 10.50 | 10.70 | 0.413 | 0.421 |
| F2 | 6.30 | 6.50 | 0.248 | 0.256 |
| F3 | 2.10 | 2.30 | 0.083 | 0.091 |
| F4 | 5.70 | 5.90 | 0.224 | 0.232 |
| F5 | 5.66 | 5.86 | 0.223 | 0.231 |
| F6 | 1.10 | 1.30 | 0.043 | 0.051 |

DOCUMENT NO.
Z8B00003328

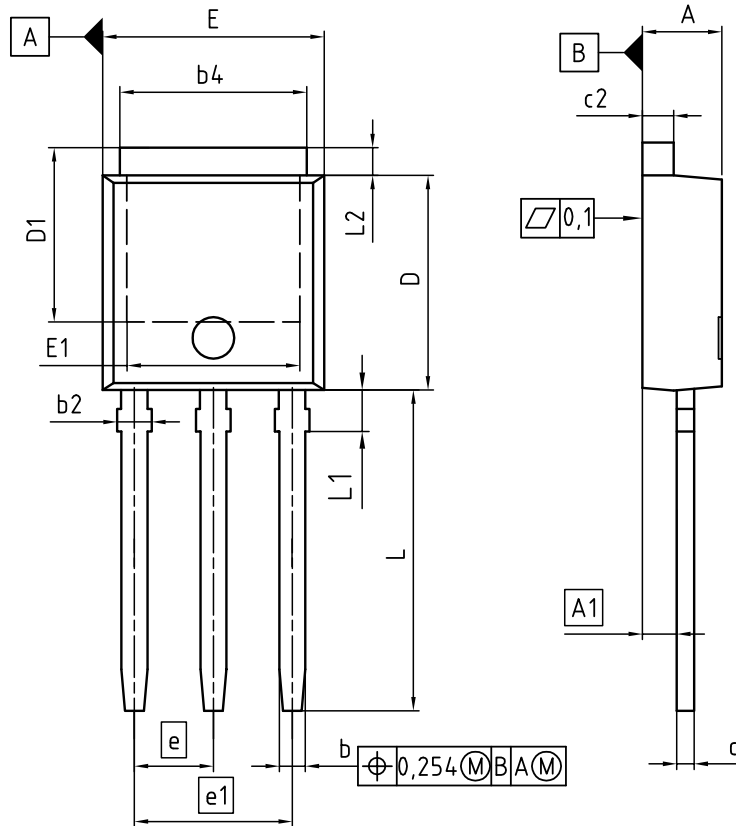
SCALE 0 2.0 4mm

EUROPEAN PROJECTION

ISSUE DATE
19-10-2007

REVISION
03

PG-TO251-3-1, PG-TO251-3-21 (I-PAK)



| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.16 | 2.41 | 0.085 | 0.095 |
| A1 | 0.90 | 1.14 | 0.035 | 0.045 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b4 | 4.95 | 5.50 | 0.195 | 0.217 |
| c | 0.46 | 0.60 | 0.018 | 0.024 |
| c2 | 0.46 | 0.89 | 0.018 | 0.035 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.04 | 5.77 | 0.198 | 0.227 |
| E | 6.35 | 6.73 | 0.250 | 0.265 |
| E1 | 4.70 | 5.21 | 0.185 | 0.205 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| L | 8.89 | 9.65 | 0.350 | 0.380 |
| L1 | 1.90 | 2.29 | 0.075 | 0.090 |
| L2 | 0.89 | 1.37 | 0.035 | 0.054 |

DOCUMENT NO.
Z8B00003330

SCALE

EUROPEAN PROJECTION

ISSUE DATE
19-03-2008

REVISION
03

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Infineon Technologies AG
81726 Munich, Germany
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