

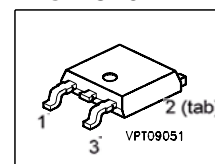
## Cool MOS™ Power Transistor

### Feature

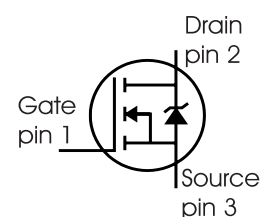
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

|                     |     |          |
|---------------------|-----|----------|
| $V_{DS} @ T_{jmax}$ | 560 | V        |
| $R_{DS(on)}$        | 3   | $\Omega$ |
| $I_D$               | 1.8 | A        |

PG-TO252



| Type       | Package  | Ordering Code | Marking |
|------------|----------|---------------|---------|
| SPD02N50C3 | PG-TO252 | Q67040-S4570  | 02N50C3 |



### Maximum Ratings

| Parameter                                                                                                                 | Symbol              | Value       | Unit             |
|---------------------------------------------------------------------------------------------------------------------------|---------------------|-------------|------------------|
| Continuous drain current<br>$T_C = 25\text{ }^\circ\text{C}$<br>$T_C = 100\text{ }^\circ\text{C}$                         | $I_D$               | 1.8<br>1.1  | A                |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$                                                                         | $I_{D\text{ puls}}$ | 5.4         |                  |
| Avalanche energy, single pulse<br>$I_D = 1.35\text{ A}$ , $V_{DD} = 50\text{ V}$                                          | $E_{AS}$            | 50          | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1</sup><br>$I_D = 1.8\text{ A}$ , $V_{DD} = 50\text{ V}$ | $E_{AR}$            | 0.07        |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$                                                              | $I_{AR}$            | 1.8         | A                |
| Gate source voltage                                                                                                       | $V_{GS}$            | $\pm 20$    | V                |
| Gate source voltage AC ( $f > 1\text{ Hz}$ )                                                                              | $V_{GS}$            | $\pm 30$    |                  |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$                                                                       | $P_{tot}$           | 25          | W                |
| Operating and storage temperature                                                                                         | $T_j, T_{stg}$      | -55... +150 | $^\circ\text{C}$ |
| Reverse diode $dv/dt$ <sup>5)</sup>                                                                                       | $dv/dt$             | 15          | V/ns             |

**Maximum Ratings**

| Parameter                                                                                                           | Symbol  | Value | Unit |
|---------------------------------------------------------------------------------------------------------------------|---------|-------|------|
| Drain Source voltage slope<br>$V_{DS} = 400 \text{ V}$ , $I_D = 1.8 \text{ A}$ , $T_j = 125 \text{ }^\circ\text{C}$ | $dv/dt$ | 50    | V/ns |

**Thermal Characteristics**

| Parameter                                                                                         | Symbol     | Values |      |      | Unit             |
|---------------------------------------------------------------------------------------------------|------------|--------|------|------|------------------|
|                                                                                                   |            | min.   | typ. | max. |                  |
| Thermal resistance, junction - case                                                               | $R_{thJC}$ | -      | -    | 5    | K/W              |
| Thermal resistance, junction - ambient, leaded                                                    | $R_{thJA}$ | -      | -    | 75   |                  |
| SMD version, device on PCB:<br>@ min. footprint<br>@ 6 cm <sup>2</sup> cooling area <sup>2)</sup> | $R_{thJA}$ | -      | -    | 75   |                  |
|                                                                                                   |            | -      | -    | 50   |                  |
| Soldering temperature, reflow soldering, MSL3<br>1.6 mm (0.063 in.) from case for 10s             | $T_{sold}$ | -      | -    | 260  | $^\circ\text{C}$ |

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

| Parameter                                   | Symbol        | Conditions                                                                                         | Values |      |      | Unit          |
|---------------------------------------------|---------------|----------------------------------------------------------------------------------------------------|--------|------|------|---------------|
|                                             |               |                                                                                                    | min.   | typ. | max. |               |
| Drain-source breakdown voltage              | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}$ , $I_D=0.25\text{mA}$                                                           | 500    | -    | -    | V             |
| Drain-Source avalanche<br>breakdown voltage | $V_{(BR)DS}$  | $V_{GS}=0\text{V}$ , $I_D=1.8\text{A}$                                                             | -      | 600  | -    |               |
| Gate threshold voltage                      | $V_{GS(th)}$  | $I_D=80\mu\text{A}$ , $V_{GS}=V_{DS}$                                                              | 2.1    | 3    | 3.9  |               |
| Zero gate voltage drain current             | $I_{DSS}$     | $V_{DS}=500\text{V}$ , $V_{GS}=0\text{V}$ ,<br>$T_j=25^\circ\text{C}$ ,<br>$T_j=150^\circ\text{C}$ | -      | 0.1  | 1    | $\mu\text{A}$ |
|                                             |               |                                                                                                    | -      | -    | 100  |               |
| Gate-source leakage current                 | $I_{GSS}$     | $V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$                                                           | -      | -    | 100  | nA            |
| Drain-source on-state resistance            | $R_{DS(on)}$  | $V_{GS}=10\text{V}$ , $I_D=1.1\text{A}$ ,<br>$T_j=25^\circ\text{C}$<br>$T_j=150^\circ\text{C}$     | -      | 2.7  | 3    | $\Omega$      |
|                                             |               |                                                                                                    | -      | 7.3  | -    |               |
| Gate input resistance                       | $R_G$         | $f=1\text{MHz}$ , open Drain                                                                       | -      | 12   | -    |               |

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

| Parameter                                                     | Symbol       | Conditions                                                                                   | Values |      |      | Unit |
|---------------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------|--------|------|------|------|
|                                                               |              |                                                                                              | min.   | typ. | max. |      |
| Transconductance                                              | $g_{fs}$     | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ ,<br>$I_D = 1.1\text{A}$                       | -      | 1.8  | -    | S    |
| Input capacitance                                             | $C_{iss}$    | $V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,<br>$f = 1\text{MHz}$                          | -      | 190  | -    | pF   |
| Output capacitance                                            | $C_{oss}$    |                                                                                              | -      | 80   | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |                                                                                              | -      | 2    | -    |      |
| Effective output capacitance, <sup>3)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0\text{V}$ ,<br>$V_{DS} = 0\text{V to } 400\text{V}$                               | -      | 9    | -    | pF   |
| Effective output capacitance, <sup>4)</sup><br>time related   | $C_{o(tr)}$  |                                                                                              | -      | 17   | -    |      |
| Turn-on delay time                                            | $t_{d(on)}$  | $V_{DD} = 350\text{V}$ , $V_{GS} = 0/10\text{V}$ ,<br>$I_D = 1.8\text{A}$ , $R_G = 25\Omega$ | -      | 10   | -    | ns   |
| Rise time                                                     | $t_r$        |                                                                                              | -      | 5    | -    |      |
| Turn-off delay time                                           | $t_{d(off)}$ |                                                                                              | -      | 70   | -    |      |
| Fall time                                                     | $t_f$        |                                                                                              | -      | 15   | -    |      |

**Gate Charge Characteristics**

|                       |                 |                                                                                       |   |     |   |    |
|-----------------------|-----------------|---------------------------------------------------------------------------------------|---|-----|---|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 400\text{V}$ , $I_D = 1.8\text{A}$                                          | - | 1.5 | - | nC |
| Gate to drain charge  | $Q_{gd}$        |                                                                                       | - | 4.5 | - |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 400\text{V}$ , $I_D = 1.8\text{A}$ ,<br>$V_{GS} = 0 \text{ to } 10\text{V}$ | - | 9   | - |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 400\text{V}$ , $I_D = 1.8\text{A}$                                          | - | 5   | - | V  |

<sup>0</sup> J-STD20 and JESD22

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

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

<sup>3</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 80%  $V_{DSS}$ .

<sup>4</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 80%  $V_{DSS}$ .

<sup>5</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 400\text{A/us}$ ,  $V_{DClink} = 400\text{V}$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .

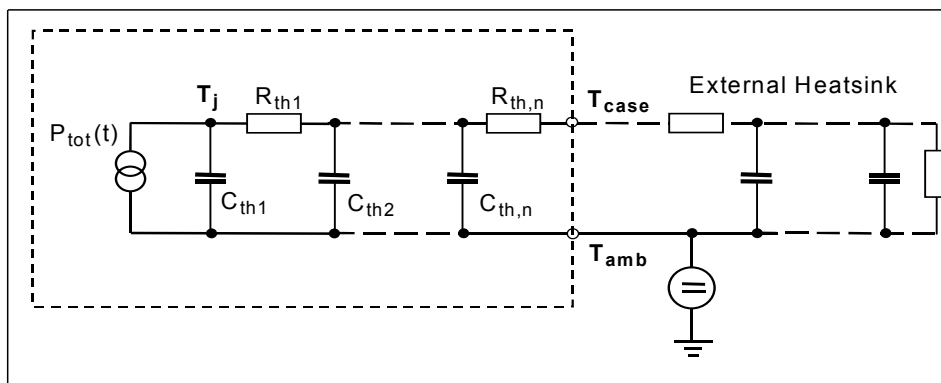
Identical low-side and high-side switch.

**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      | $I_S$        | $T_C=25^{\circ}\text{C}$                                             | -      | -    | 1.8  | A                      |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                                                      | -      | -    | 5.4  |                        |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0\text{V}$ , $I_F=I_S$                                       | -      | 1    | 1.2  | V                      |
| Reverse recovery time                         | $t_{rr}$     | $V_R=400\text{V}$ , $I_F=I_S$ ,<br>$di_F/dt=100\text{A}/\mu\text{s}$ | -      | 180  | -    | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     |                                                                      | -      | 1.2  | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                                                      | -      | 8    | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ |                                                                      | -      | 200  | -    | $\text{A}/\mu\text{s}$ |

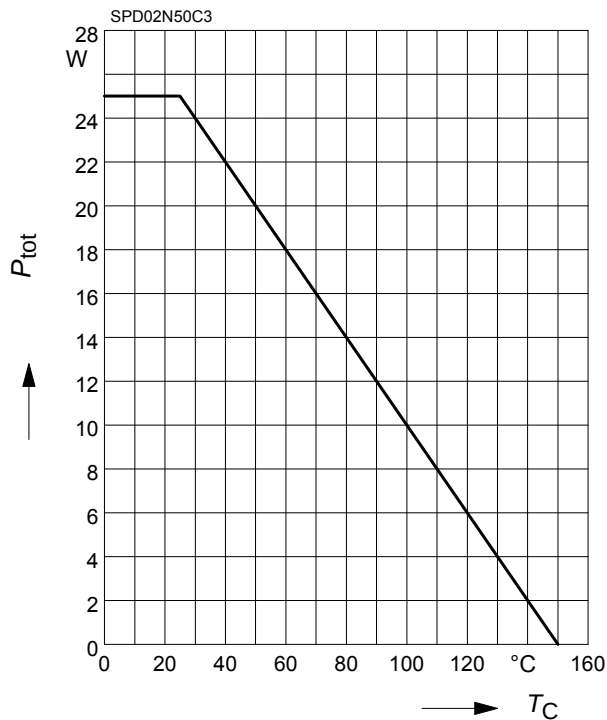
### Typical Transient Thermal Characteristics

| Symbol             | Value | Unit | Symbol              | Value      | Unit |
|--------------------|-------|------|---------------------|------------|------|
|                    | typ.  |      |                     | typ.       |      |
| Thermal resistance |       |      | Thermal capacitance |            |      |
| $R_{th1}$          | 0.1   | K/W  | $C_{th1}$           | 0.00002806 | Ws/K |
| $R_{th2}$          | 0.184 |      | $C_{th2}$           | 0.0001113  |      |
| $R_{th3}$          | 0.306 |      | $C_{th3}$           | 0.0001679  |      |
| $R_{th4}$          | 1.207 |      | $C_{th4}$           | 0.000547   |      |
| $R_{th5}$          | 0.974 |      | $C_{th5}$           | 0.001388   |      |
| $R_{th6}$          | 0.251 |      | $C_{th6}$           | 0.019      |      |



### 1 Power dissipation

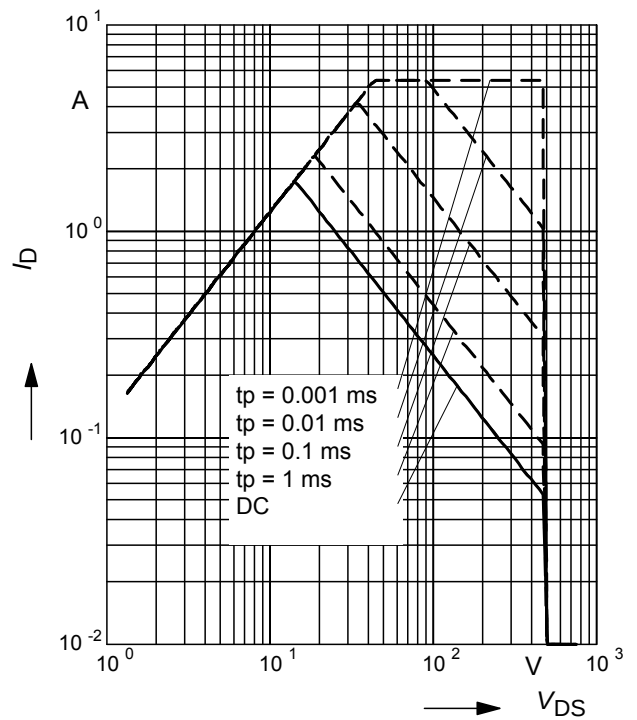
$$P_{\text{tot}} = f(T_C)$$



### 2 Safe operating area

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

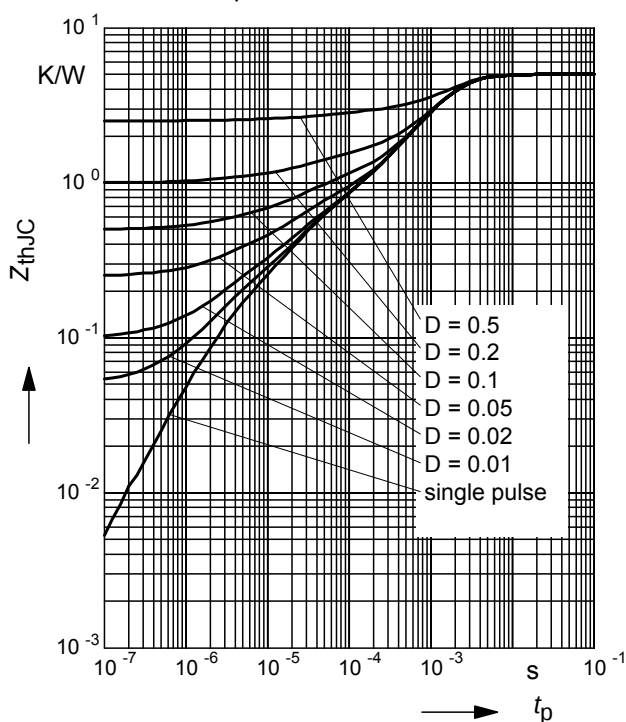
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

$$Z_{\text{thJC}} = f(t_p)$$

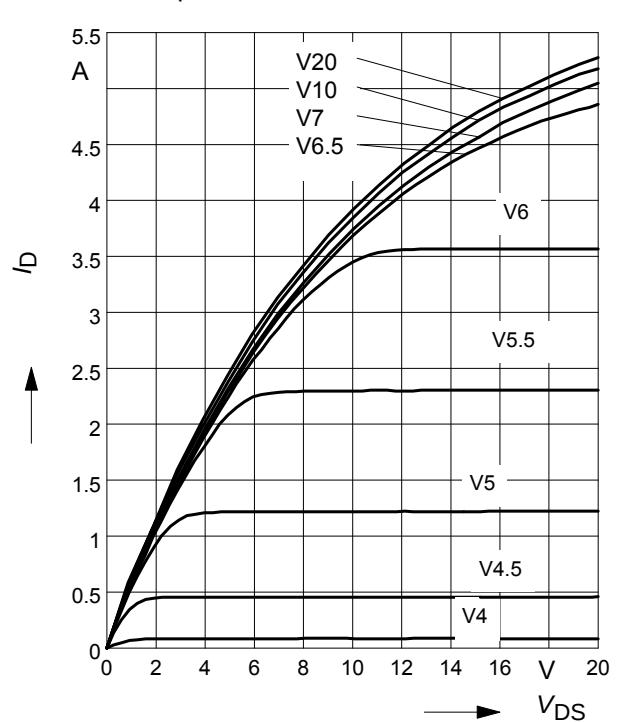
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

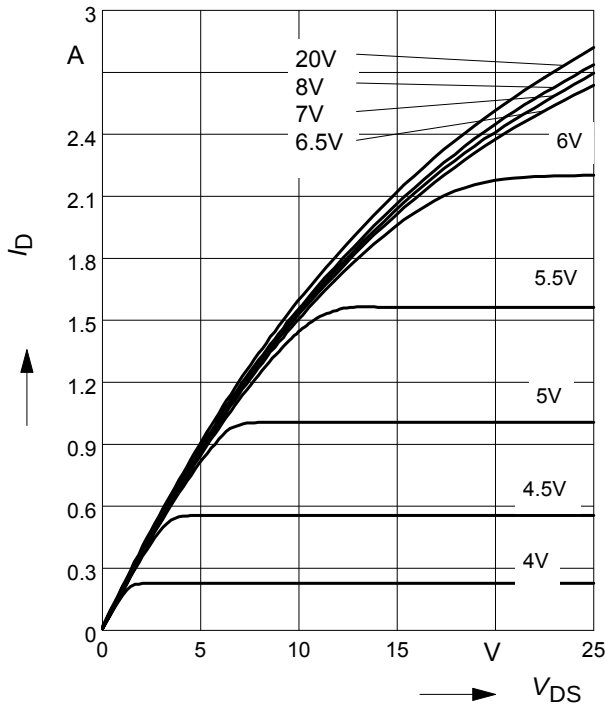
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



**5 Typ. output characteristic**

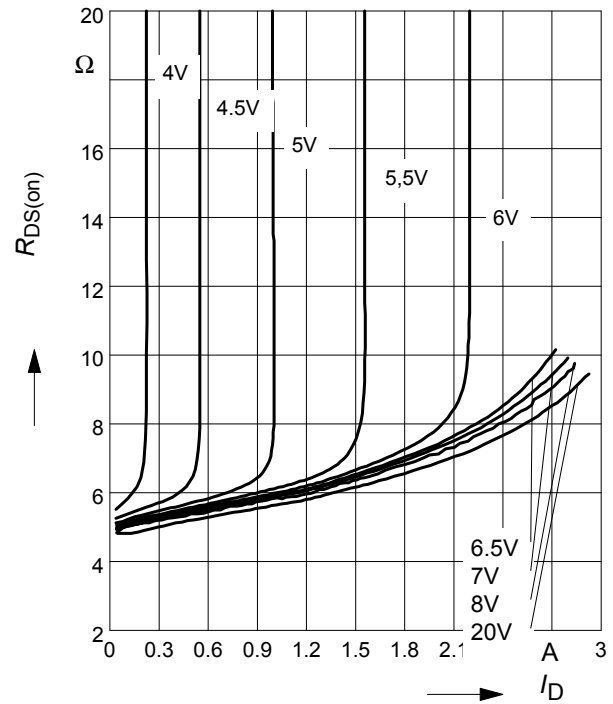
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

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


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

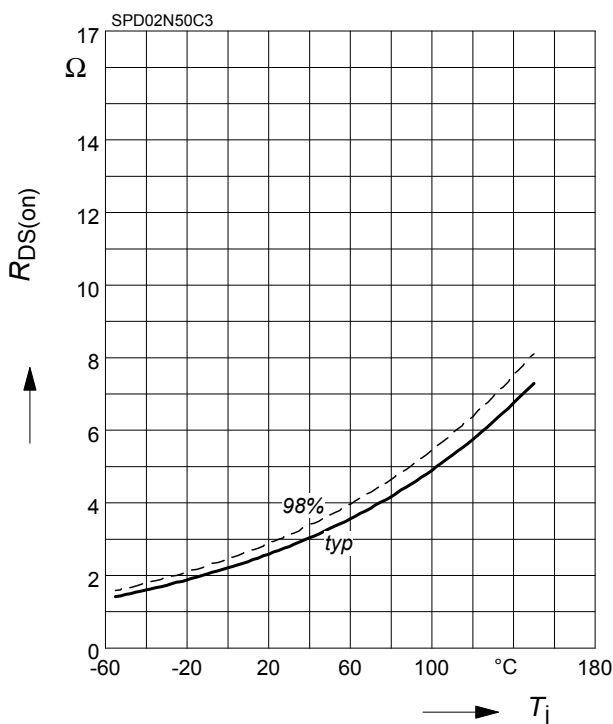
$$R_{DS(on)} = f(I_D)$$

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


**7 Drain-source on-state resistance**

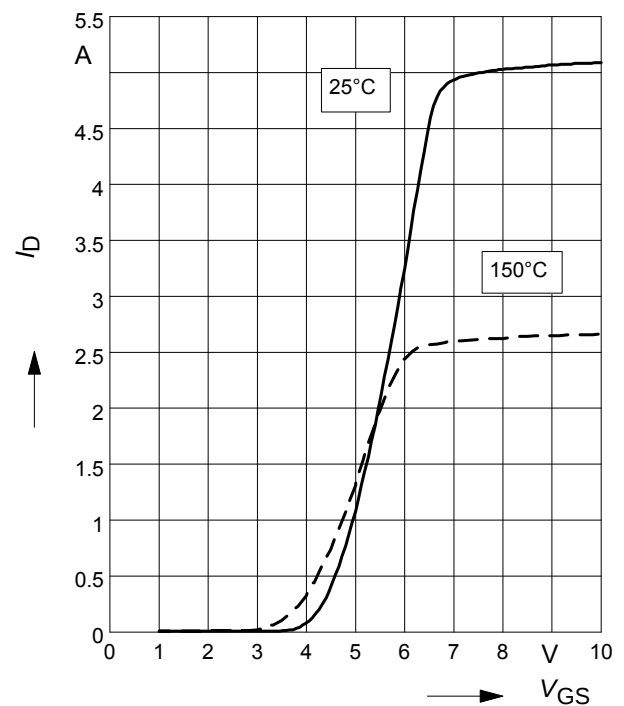
$$R_{DS(on)} = f(T_j)$$

parameter:  $I_D = 1.1 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$


**8 Typ. transfer characteristics**

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

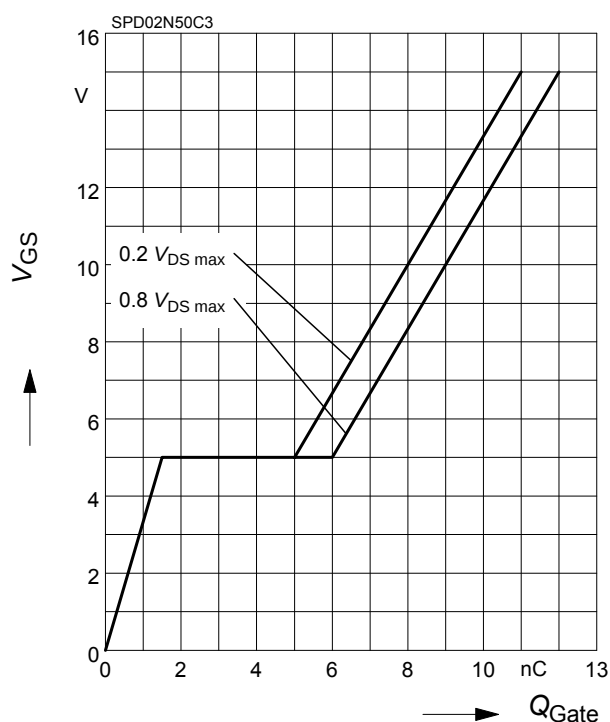
parameter:  $t_p = 10 \mu\text{s}$



## 9 Typ. gate charge

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

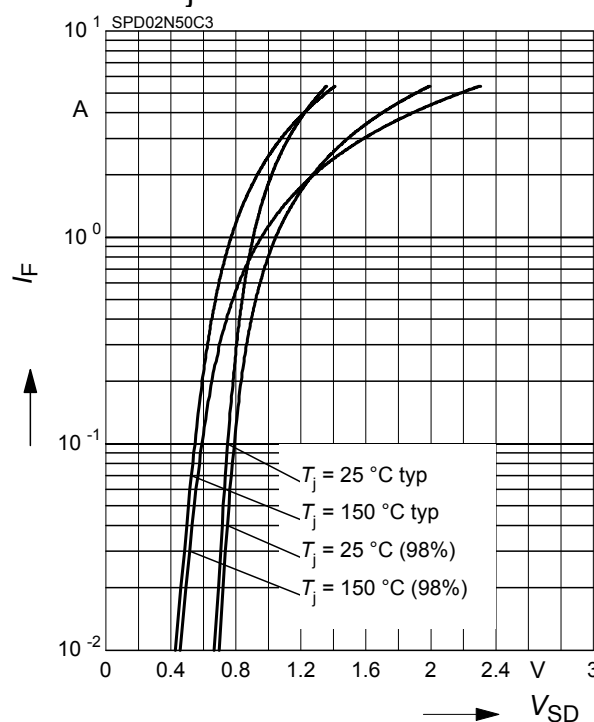
parameter:  $I_D = 1.8 \text{ A}$  pulsed



## 10 Forward characteristics of body diode

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

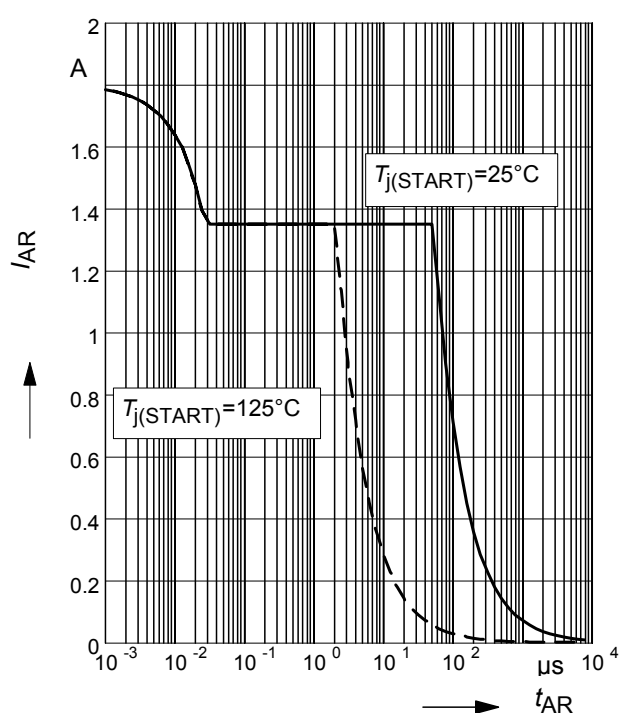
parameter:  $T_j$ ,  $t_p = 10 \mu\text{s}$



## 11 Avalanche SOA

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

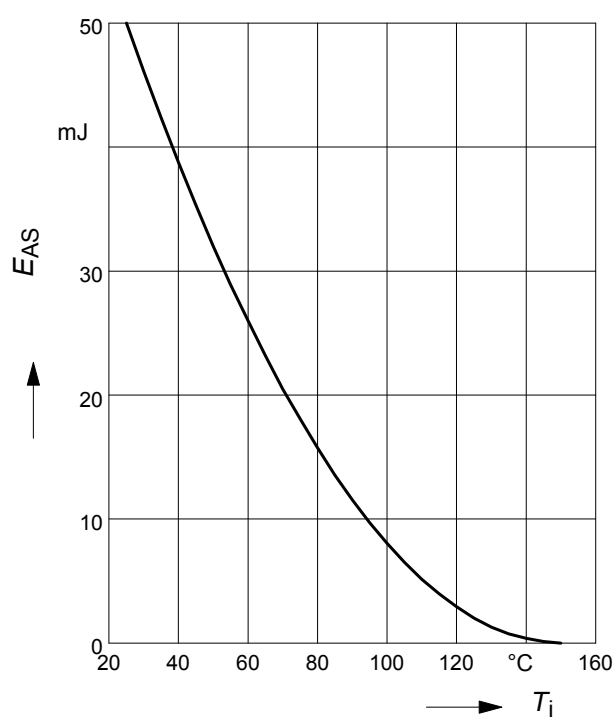
par.:  $T_j \leq 150 \text{ °C}$



## 12 Avalanche energy

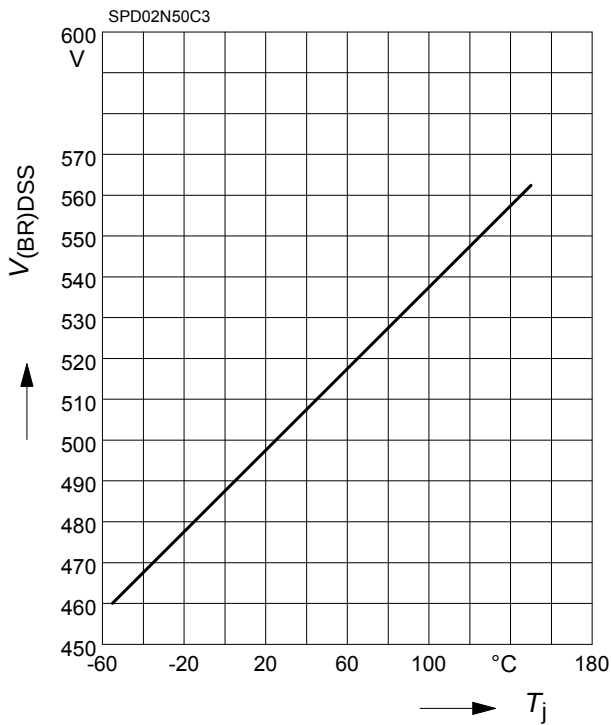
$$E_{AS} = f(T_j)$$

par.:  $I_D = 1.35 \text{ A}$ ,  $V_{DD} = 50 \text{ V}$



### 13 Drain-source breakdown voltage

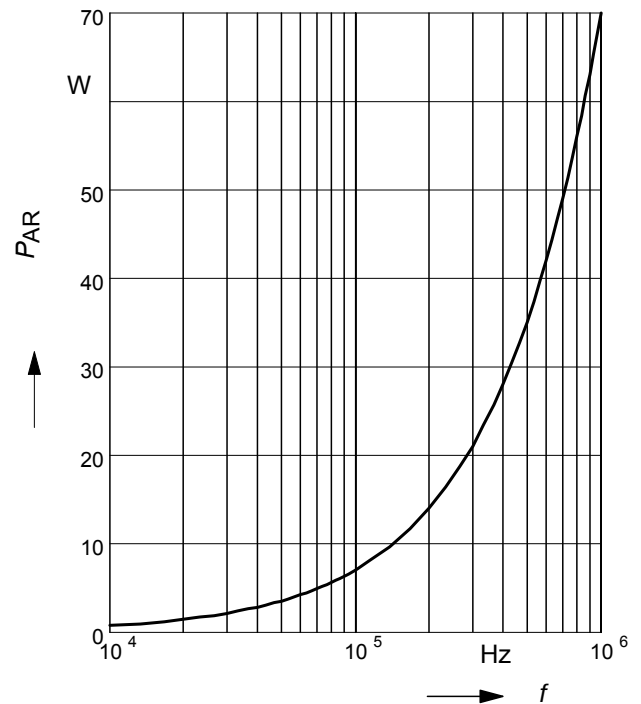
$$V_{(BR)DSS} = f(T_j)$$



### 14 Avalanche power losses

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

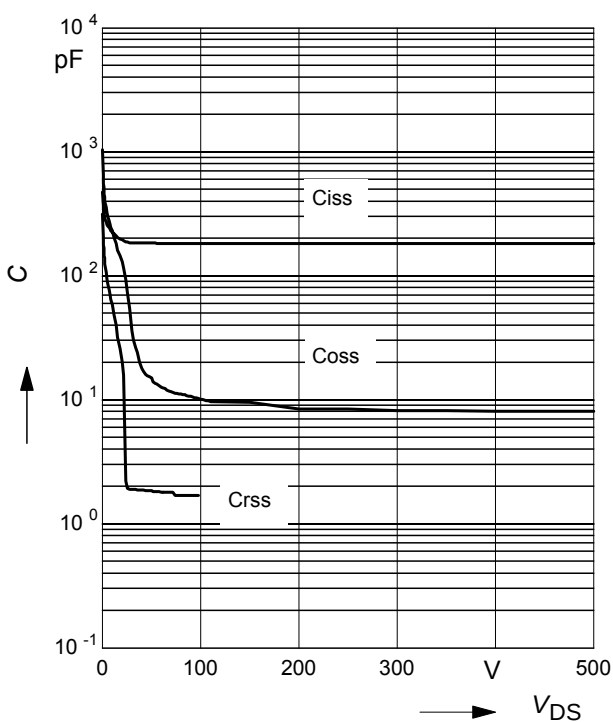
parameter:  $E_{AR}=0.07\text{mJ}$



### 15 Typ. capacitances

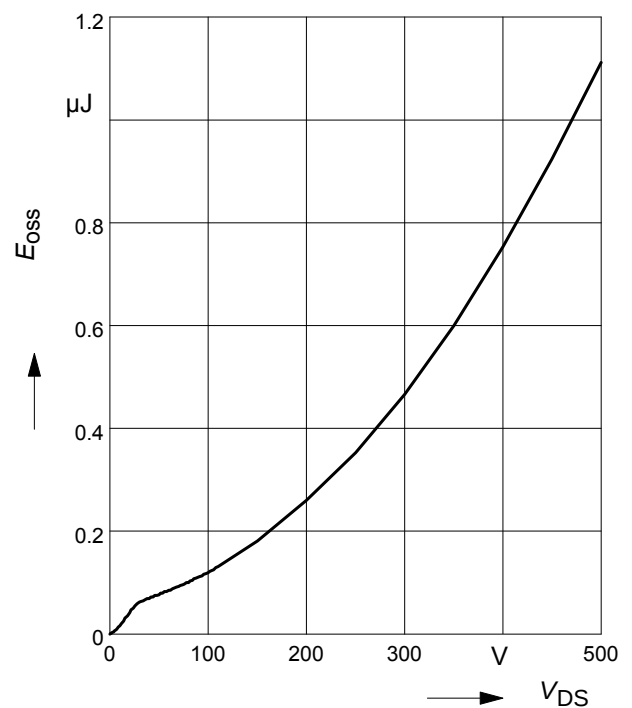
$$C = f(V_{DS})$$

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

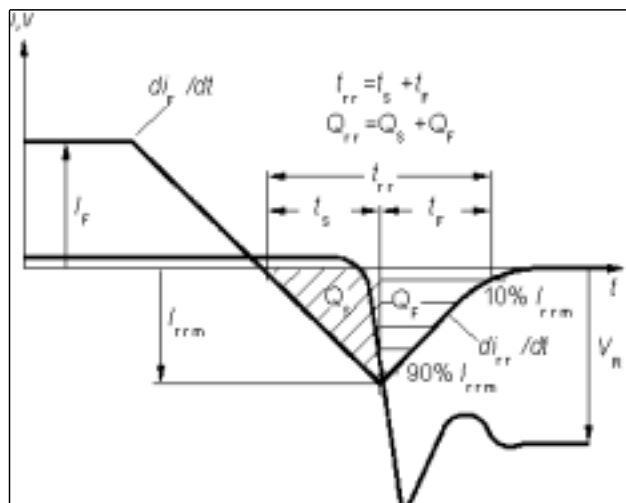


### 16 Typ. $C_{OSS}$ stored energy

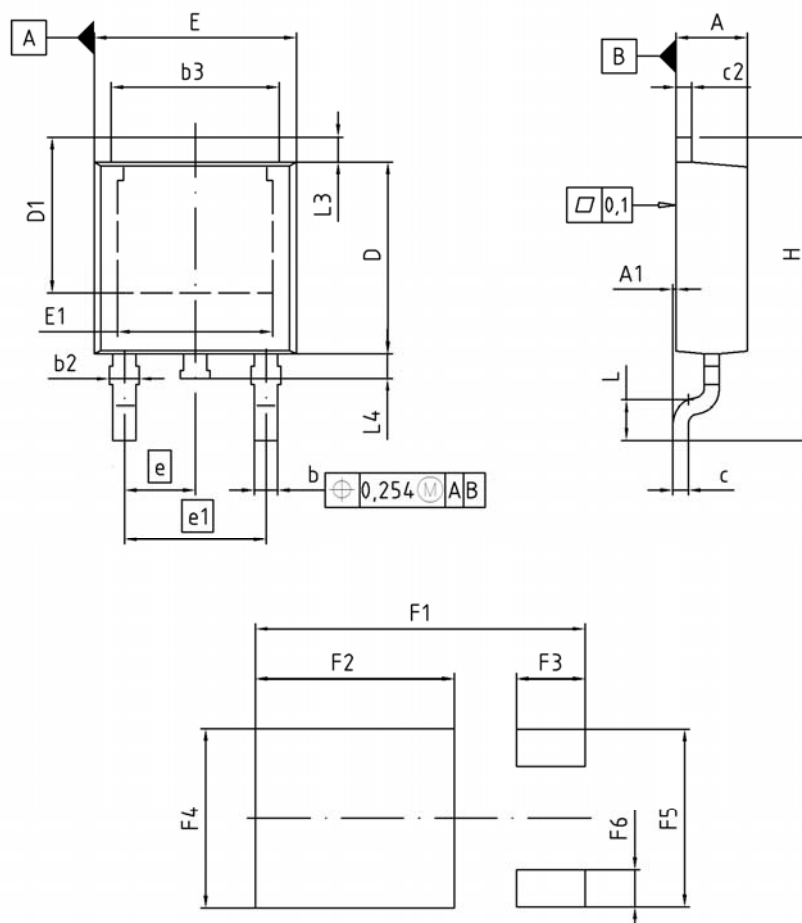
$$E_{OSS}=f(V_{DS})$$



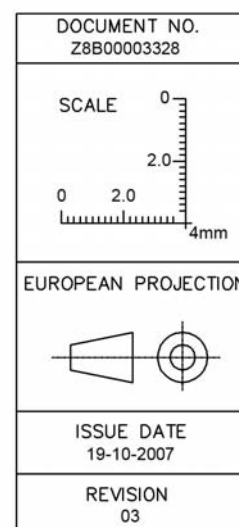
### Definition of diodes switching characteristics



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 |



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