

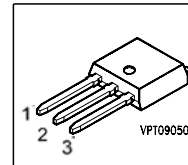
## Cool MOS™ Power Transistor

### Feature

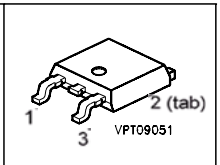
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

|                     |     |          |
|---------------------|-----|----------|
| $V_{DS} @ T_{jmax}$ | 650 | V        |
| $R_{DS(on)}$        | 1.4 | $\Omega$ |
| $I_D$               | 3.2 | A        |

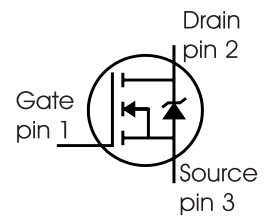
PG-T0251



PG-T0252



| Type       | Package  | Ordering Code | Marking |
|------------|----------|---------------|---------|
| SPD03N60C3 | PG-T0252 | Q67040-S4421  | 03N60C3 |
| SPU03N60C3 | PG-T0251 |               | 03N60C3 |



### Maximum Ratings

| Parameter                                                                                                                 | Symbol              | Value       | Unit             |
|---------------------------------------------------------------------------------------------------------------------------|---------------------|-------------|------------------|
| Continuous drain current<br>$T_C = 25\text{ }^\circ\text{C}$<br>$T_C = 100\text{ }^\circ\text{C}$                         | $I_D$               | 3.2<br>2    | A                |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$                                                                         | $I_{D\text{ puls}}$ | 9.6         |                  |
| Avalanche energy, single pulse<br>$I_D = 2.4\text{ A}$ , $V_{DD} = 50\text{ V}$                                           | $E_{AS}$            | 100         | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1</sup><br>$I_D = 3.2\text{ A}$ , $V_{DD} = 50\text{ V}$ | $E_{AR}$            | 0.2         |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$                                                              | $I_{AR}$            | 3.2         | A                |
| Gate source voltage static                                                                                                | $V_{GS}$            | $\pm 20$    | V                |
| Gate source voltage AC ( $f > 1\text{ Hz}$ )                                                                              | $V_{GS}$            | $\pm 30$    |                  |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$                                                                       | $P_{tot}$           | 38          | 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>$V_{DS} = 480 \text{ V}$ , $I_D = 3.2 \text{ A}$ , $T_j = 125 \text{ }^\circ\text{C}$ | $dv/dt$ | 50    | V/ns |

**Thermal Characteristics**

| Parameter                                                                                         | Symbol     | Values |      |          | Unit             |
|---------------------------------------------------------------------------------------------------|------------|--------|------|----------|------------------|
|                                                                                                   |            | min.   | typ. | max.     |                  |
| Thermal resistance, junction - case                                                               | $R_{thJC}$ | -      | -    | 3.3      | 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<br>50 |                  |
| Soldering temperature, *)<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           | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}$ , $I_D=0.25\text{mA}$                                                           | 600    | -           | -        | V             |
| Drain-Source avalanche breakdown voltage | $V_{(BR)DS}$  | $V_{GS}=0\text{V}$ , $I_D=3.2\text{A}$                                                             | -      | 700         | -        |               |
| Gate threshold voltage                   | $V_{GS(th)}$  | $I_D=135\mu\text{A}$ , $V_{GS}=V_{DS}$                                                             | 2.1    | 3           | 3.9      |               |
| Zero gate voltage drain current          | $I_{DSS}$     | $V_{DS}=600\text{V}$ , $V_{GS}=0\text{V}$ ,<br>$T_j=25^\circ\text{C}$ ,<br>$T_j=150^\circ\text{C}$ | -<br>- | 0.5<br>-    | 1<br>70  | $\mu\text{A}$ |
| Gate-source leakage current              | $I_{GSS}$     | $V_{GS}=30\text{V}$ , $V_{DS}=0\text{V}$                                                           | -      | -           | 100      |               |
| Drain-source on-state resistance         | $R_{DS(on)}$  | $V_{GS}=10\text{V}$ , $I_D=2\text{A}$ ,<br>$T_j=25^\circ\text{C}$ ,<br>$T_j=150^\circ\text{C}$     | -<br>- | 1.26<br>3.8 | 1.4<br>- | $\Omega$      |
| Gate input resistance                    | $R_G$         | $f=1\text{MHz}$ , open Drain                                                                       | -      | 10          | -        |               |

\*) 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. |      |
| Transconductance                                              | $g_{fs}$     | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ ,<br>$I_D = 2\text{A}$                         | -      | 3.4  | -    | S    |
| Input capacitance                                             | $C_{iss}$    | $V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,<br>$f = 1\text{MHz}$                          | -      | 400  | -    | pF   |
| Output capacitance                                            | $C_{oss}$    |                                                                                              | -      | 150  | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |                                                                                              | -      | 5    | -    |      |
| Effective output capacitance, <sup>3)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0\text{V}$ ,<br>$V_{DS} = 0\text{V to } 480\text{V}$                               | -      | 12   | -    | pF   |
| Effective output capacitance, <sup>4)</sup><br>time related   | $C_{o(tr)}$  |                                                                                              | -      | 26   | -    |      |
| Turn-on delay time                                            | $t_{d(on)}$  | $V_{DD} = 350\text{V}$ , $V_{GS} = 0/10\text{V}$ ,<br>$I_D = 3.2\text{A}$ , $R_G = 20\Omega$ | -      | 7    | -    | ns   |
| Rise time                                                     | $t_r$        |                                                                                              | -      | 3    | -    |      |
| Turn-off delay time                                           | $t_{d(off)}$ |                                                                                              | -      | 64   | 100  |      |
| Fall time                                                     | $t_f$        |                                                                                              | -      | 12   | 20   |      |

**Gate Charge Characteristics**

|                       |                 |                                                                                      |   |     |    |    |
|-----------------------|-----------------|--------------------------------------------------------------------------------------|---|-----|----|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 420\text{V}$ , $I_D = 3.2\text{A}$                                         | - | 2   | -  | nC |
| Gate to drain charge  | $Q_{gd}$        |                                                                                      | - | 6   | -  |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 420\text{V}$ , $I_D = 3.2\text{A}$ ,<br>$V_{GS} = 0\text{ to } 10\text{V}$ | - | 13  | 17 |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 420\text{V}$ , $I_D = 3.2\text{A}$                                         | - | 5.5 | -  | 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> $I_{SD} \leq I_D$ ,  $di/dt \leq 400\text{A}/\mu\text{s}$ ,  $V_{DClamp} = 400\text{V}$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_J < T_{J,max}$ .

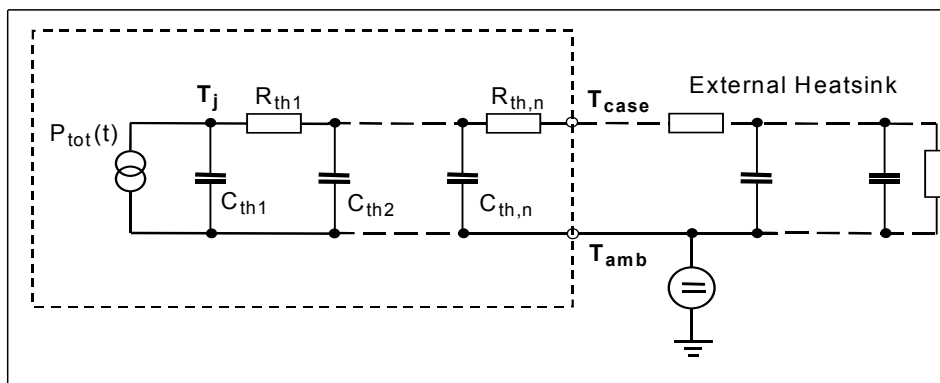
Identical low-side and high-side switch.

**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      | $I_S$        | $T_C=25^{\circ}\text{C}$                                             | -      | -    | 3.2  | A                      |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                                                      | -      | -    | 9.6  |                        |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0\text{V}$ , $I_F=I_S$                                       | -      | 1    | 1.2  | V                      |
| Reverse recovery time                         | $t_{rr}$     | $V_R=420\text{V}$ , $I_F=I_S$ ,<br>$di_F/dt=100\text{A}/\mu\text{s}$ | -      | 250  | 400  | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     |                                                                      | -      | 1.8  | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                                                      | -      | 15   | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ |                                                                      | -      | -    | 540  | $\text{A}/\mu\text{s}$ |

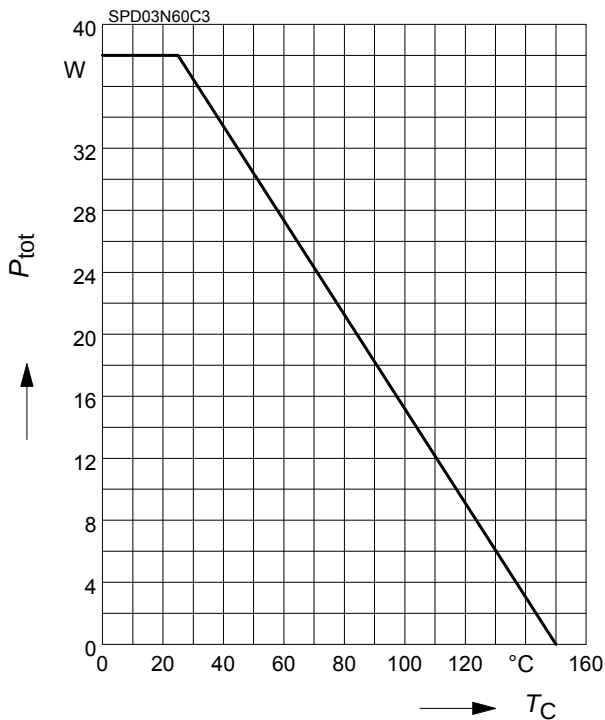
### Typical Transient Thermal Characteristics

| Symbol             | Value | Unit | Symbol              | Value      | Unit |
|--------------------|-------|------|---------------------|------------|------|
|                    | typ.  |      |                     | typ.       |      |
| Thermal resistance |       |      | Thermal capacitance |            |      |
| $R_{th1}$          | 0.054 | K/W  | $C_{th1}$           | 0.00005232 | Ws/K |
| $R_{th2}$          | 0.103 |      | $C_{th2}$           | 0.0002034  |      |
| $R_{th3}$          | 0.178 |      | $C_{th3}$           | 0.0002963  |      |
| $R_{th4}$          | 0.757 |      | $C_{th4}$           | 0.0009103  |      |
| $R_{th5}$          | 0.682 |      | $C_{th5}$           | 0.002084   |      |
| $R_{th6}$          | 0.202 |      | $C_{th6}$           | 0.024      |      |



### 1 Power dissipation

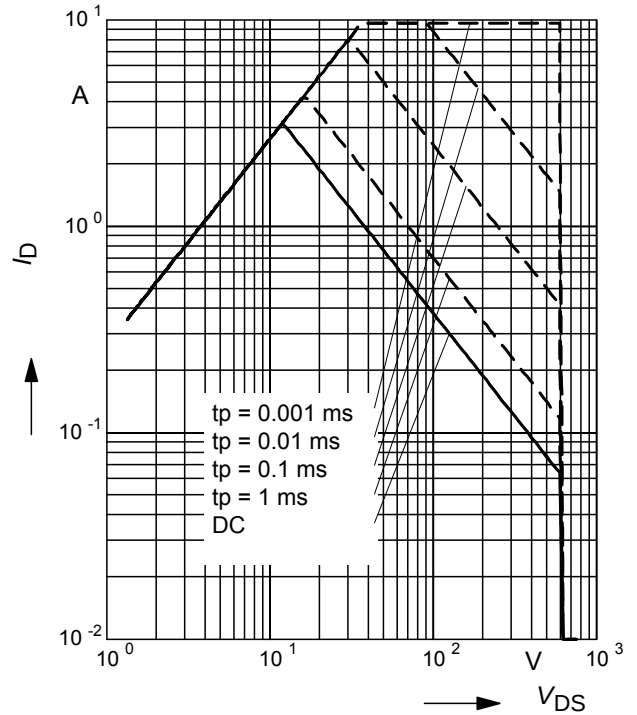
$$P_{\text{tot}} = f(T_C)$$



### 2 Safe operating area

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

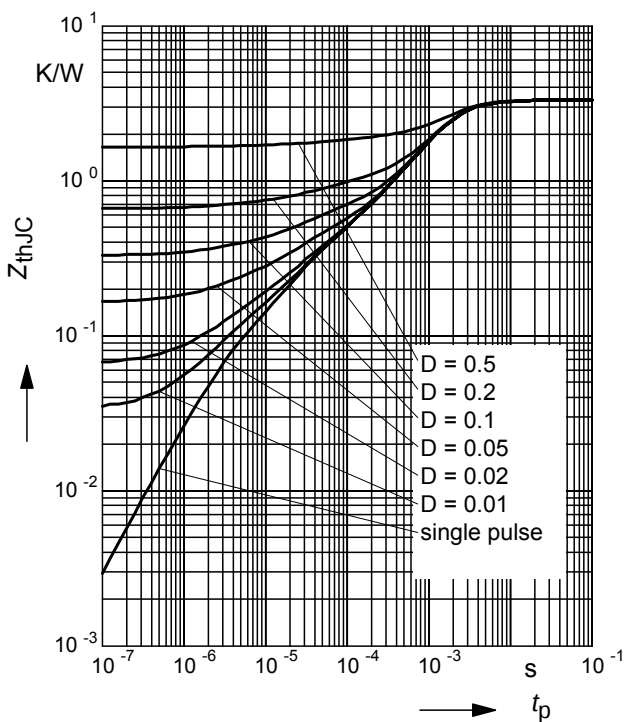
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

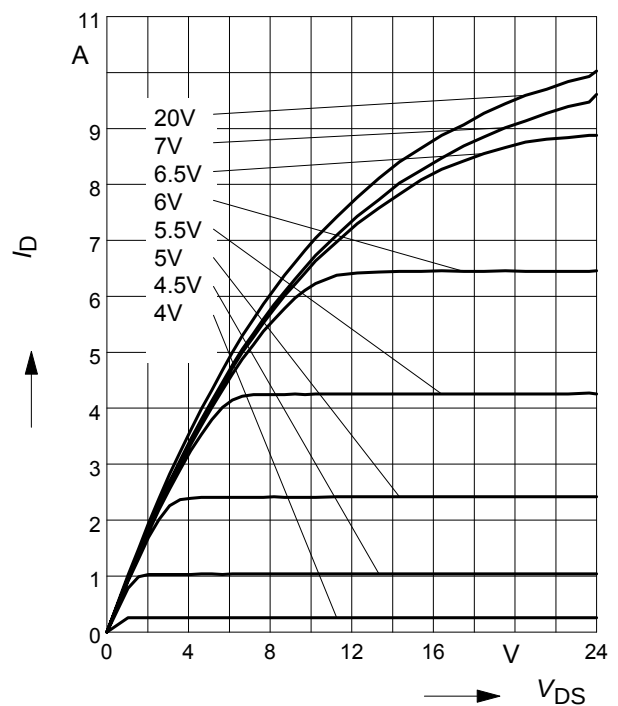
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

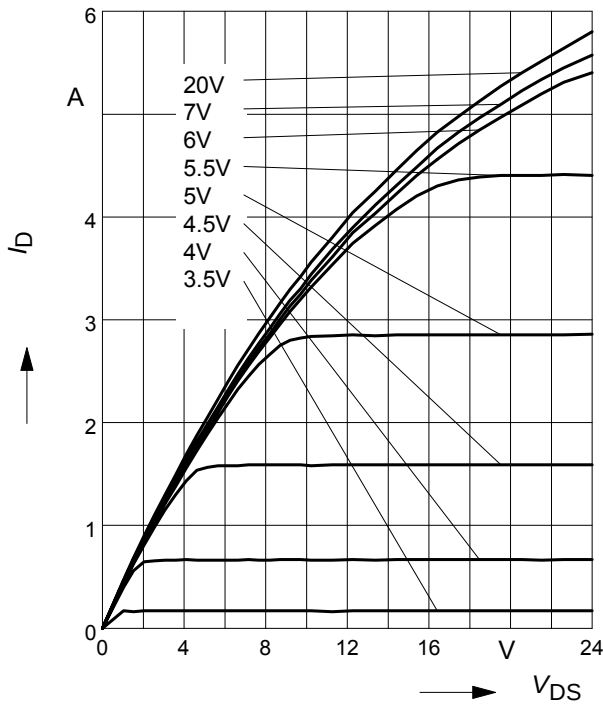
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



### 5 Typ. output characteristic

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

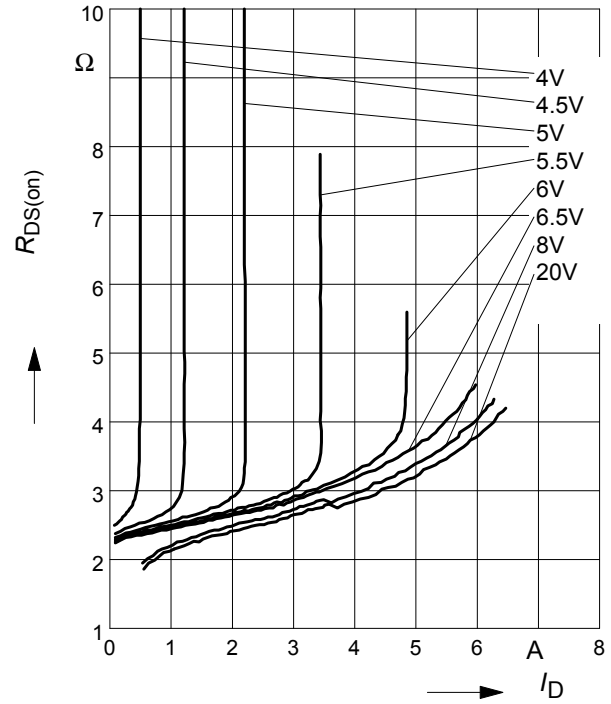
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



### 6 Typ. drain-source on resistance

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

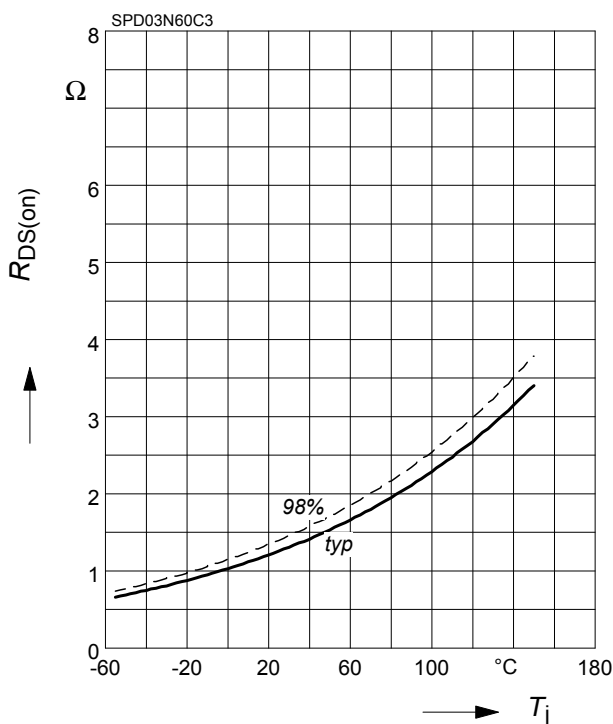
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



### 7 Drain-source on-state resistance

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

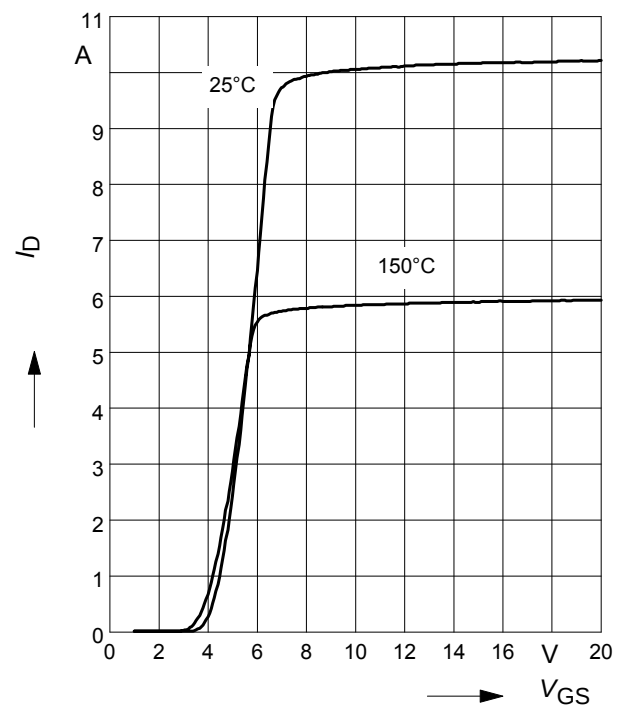
parameter:  $I_D = 2 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$



### 8 Typ. transfer characteristics

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

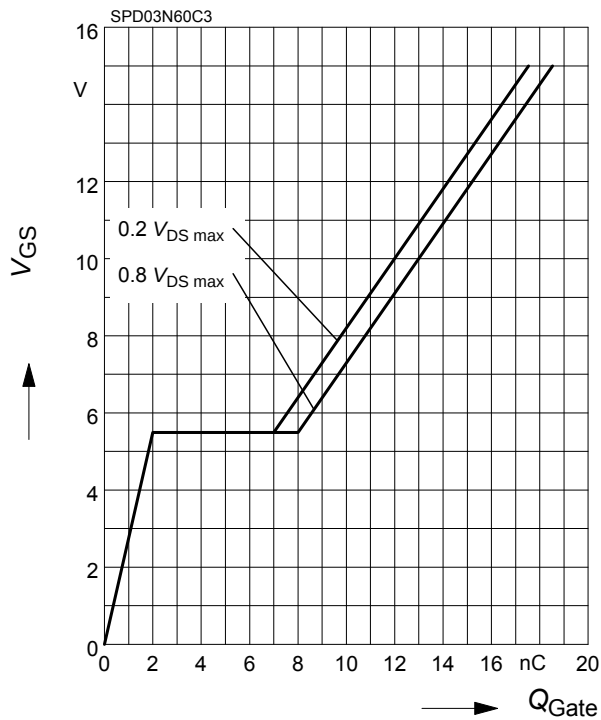
parameter:  $t_p = 10 \mu\text{s}$



### 9 Typ. gate charge

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

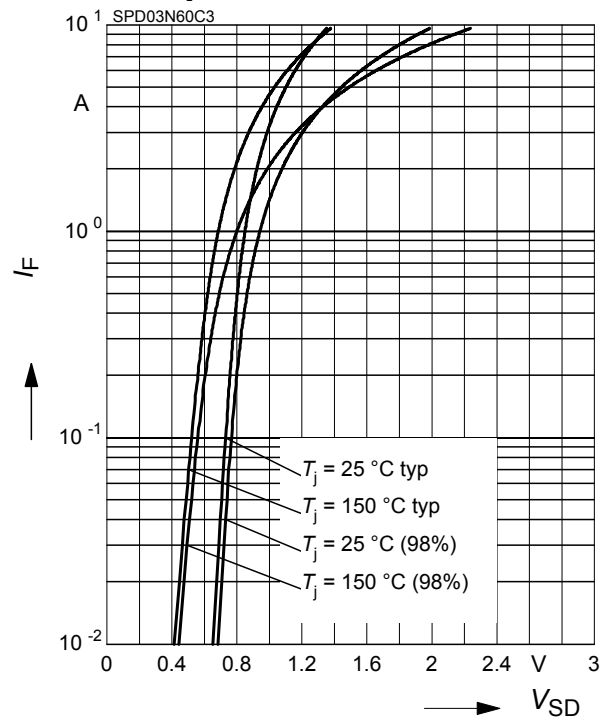
parameter:  $I_D = 3.2$  A pulsed



### 10 Forward characteristics of body diode

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

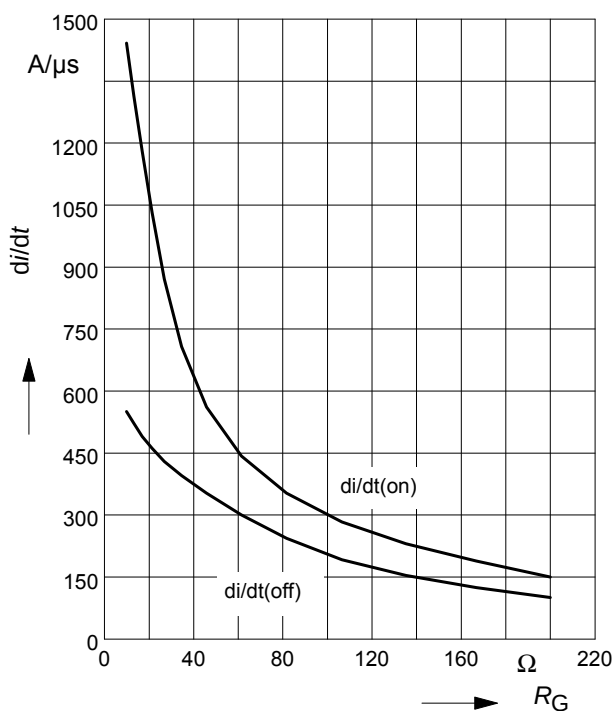
parameter:  $T_j$ ,  $t_p = 10$   $\mu$ s



### 11 Typ. drain current slope

$$di/dt = f(R_G), \text{ inductive load, } T_j = 125^\circ\text{C}$$

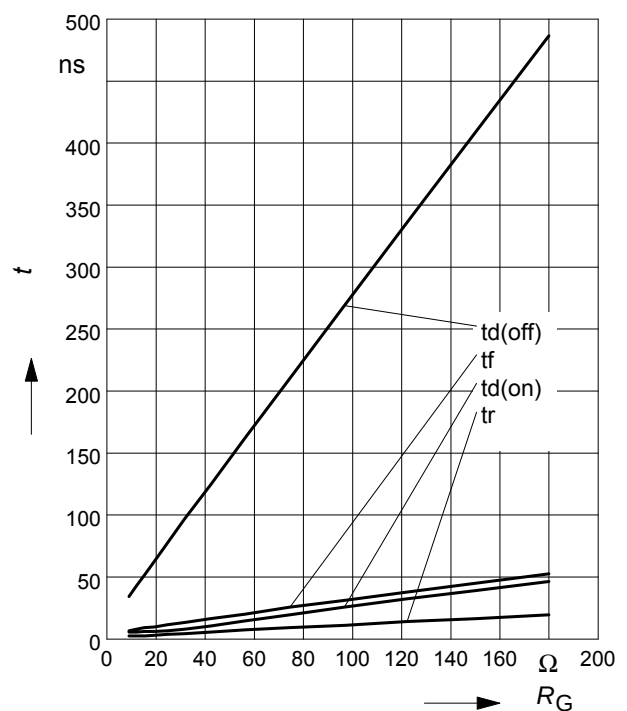
par.:  $V_{DS}=380$ V,  $V_{GS}=0/+13$ V,  $I_D=3.2$ A



### 12 Typ. switching time

$$t = f(R_G), \text{ inductive load, } T_j=125^\circ\text{C}$$

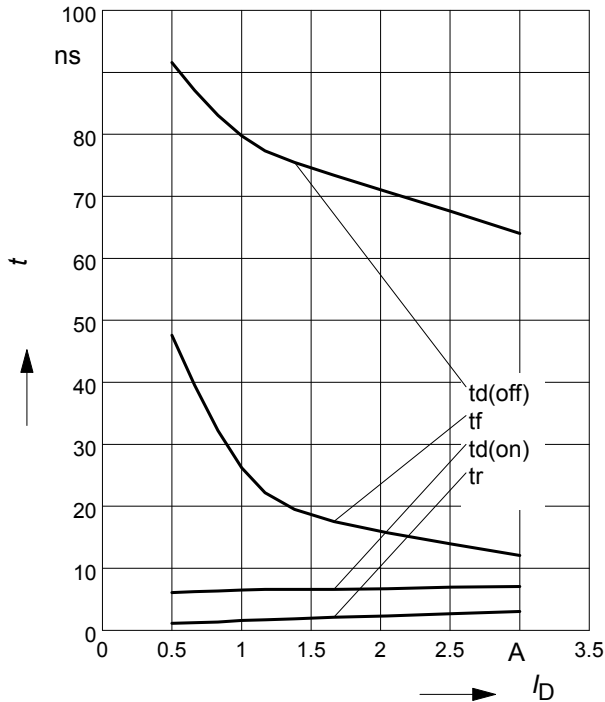
par.:  $V_{DS}=380$ V,  $V_{GS}=0/+13$ V,  $I_D=3.2$  A



### 13 Typ. switching time

$t = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$

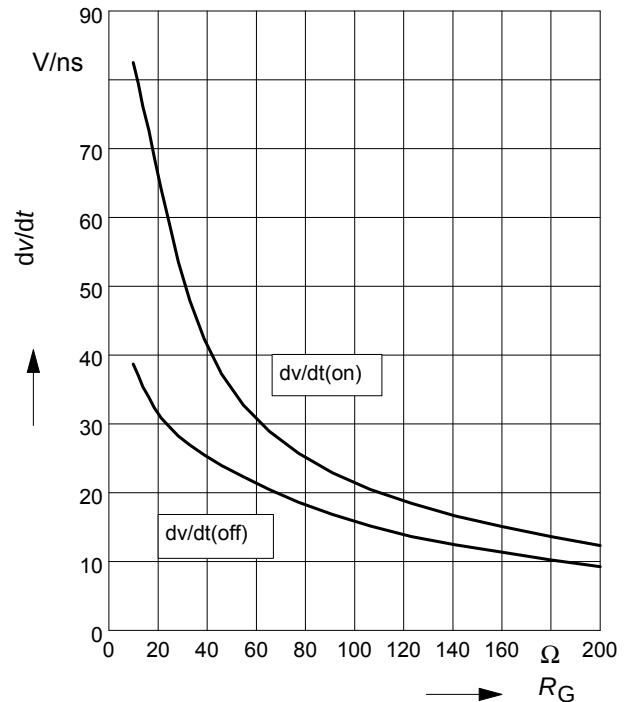
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 20\Omega$



### 14 Typ. drain source voltage slope

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$

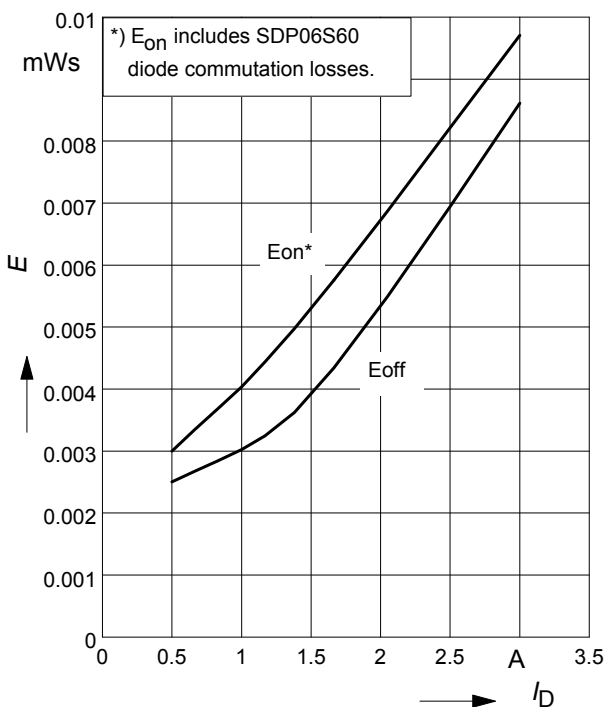
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 3.2\text{A}$



### 15 Typ. switching losses

$E = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$

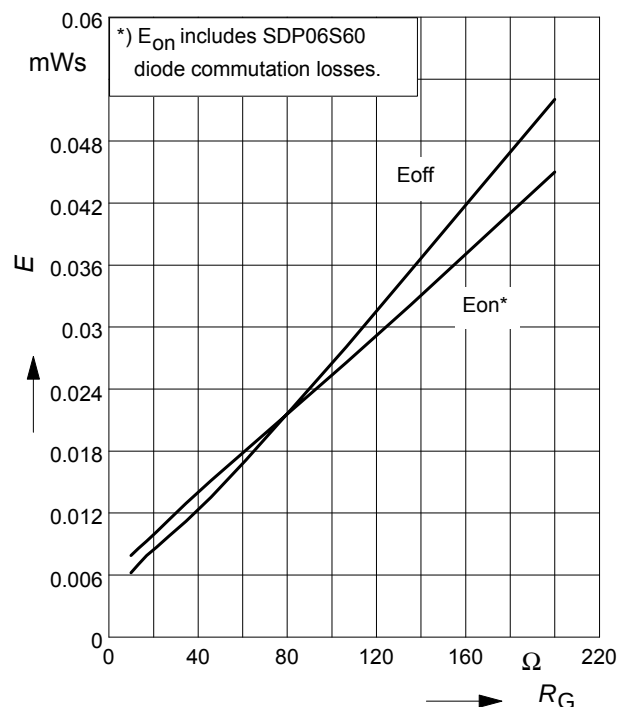
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 20\Omega$



### 16 Typ. switching losses

$E = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$

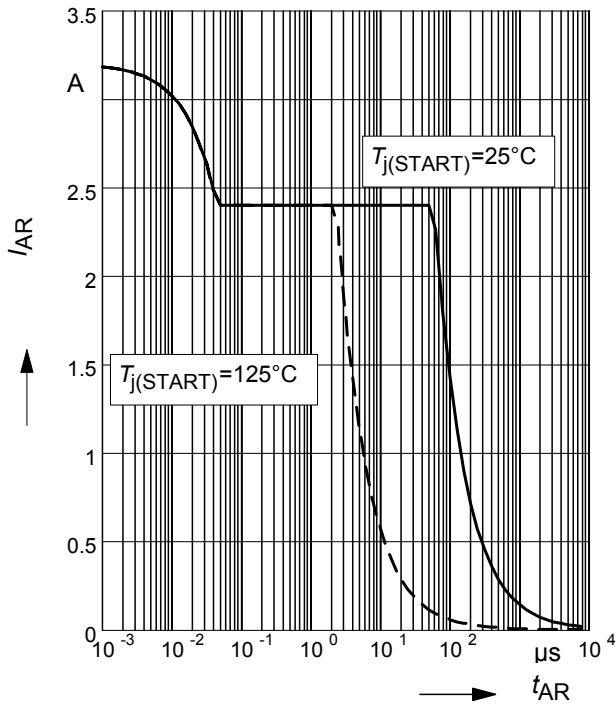
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 3.2\text{A}$



### 17 Avalanche SOA

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

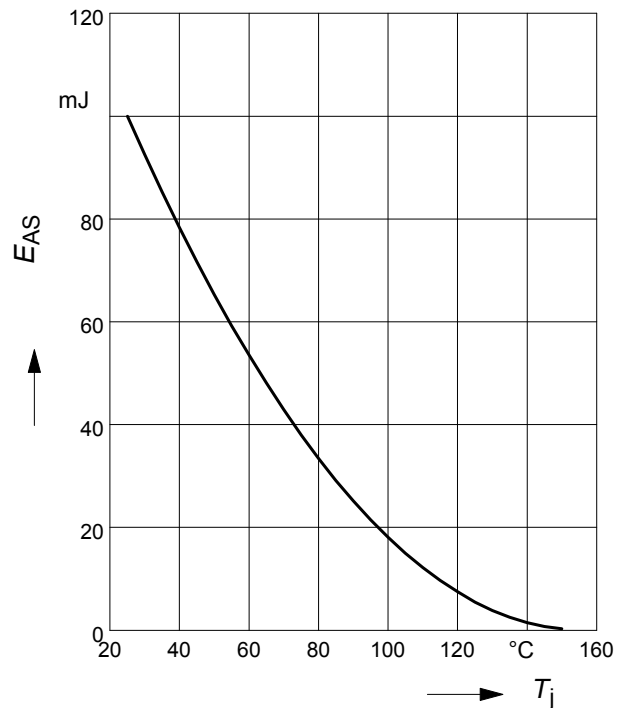
par.:  $T_j \leq 150^\circ\text{C}$



### 18 Avalanche energy

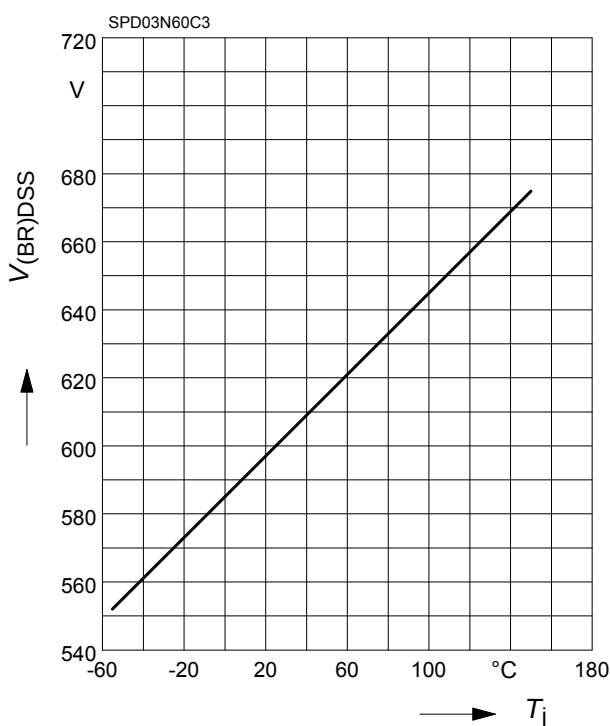
$$E_{AS} = f(T_j)$$

par.:  $I_D = 2.4\text{ A}$ ,  $V_{DD} = 50\text{ V}$



### 19 Drain-source breakdown voltage

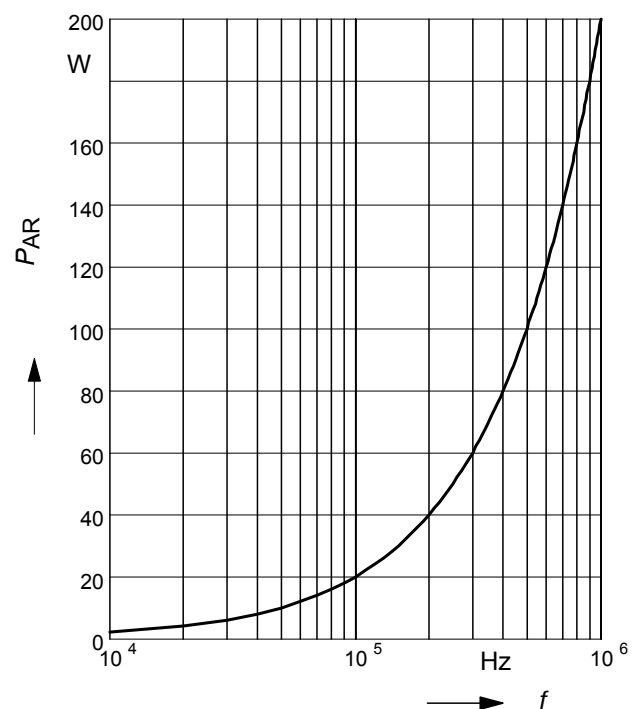
$$V_{(BR)DSS} = f(T_j)$$



### 20 Avalanche power losses

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

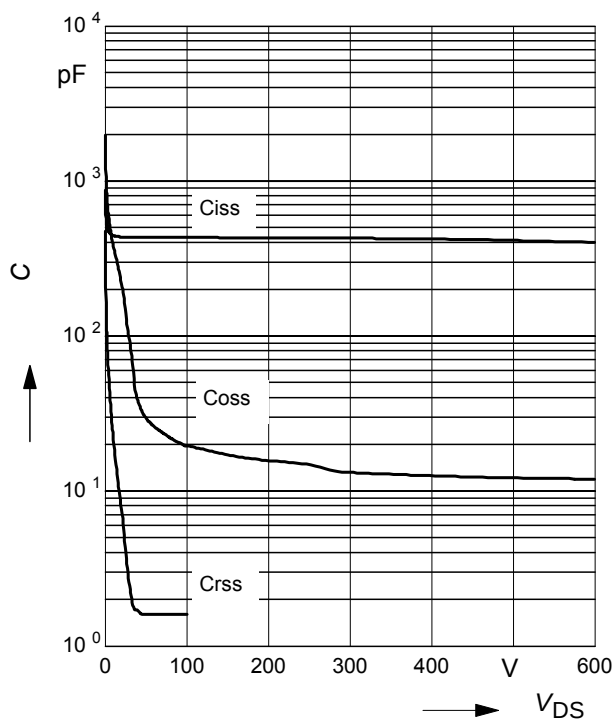
parameter:  $E_{AR} = 0.2\text{ mJ}$



## 21 Typ. capacitances

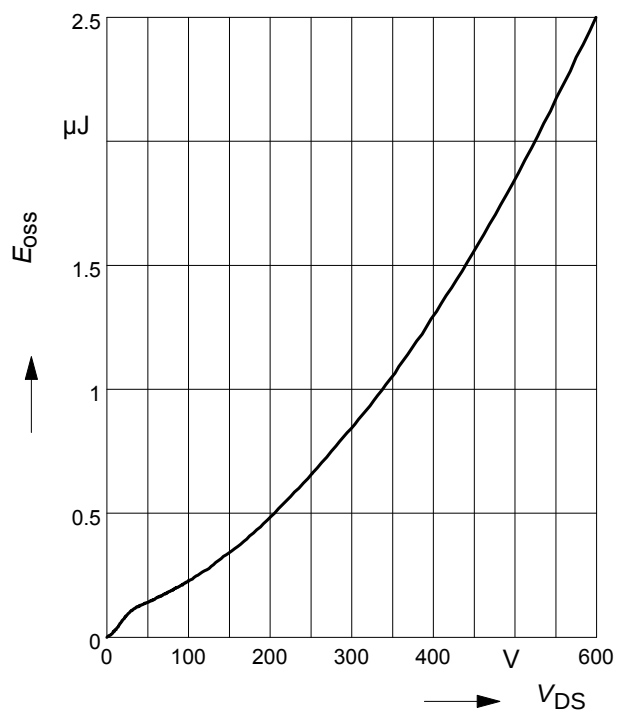
$$C = f(V_{DS})$$

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

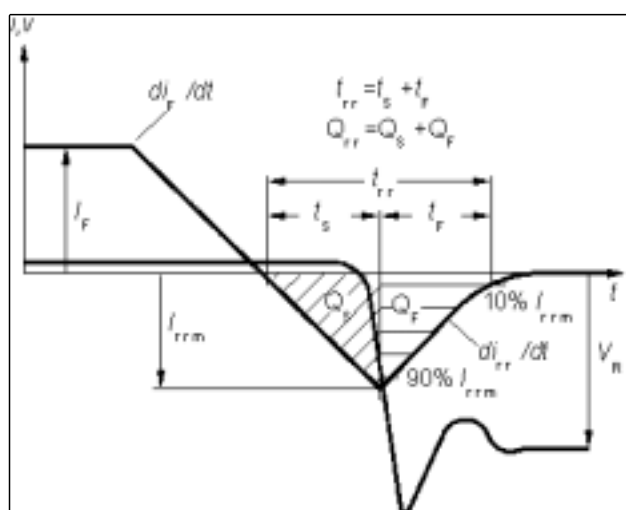


## 22 Typ. $C_{oss}$ stored energy

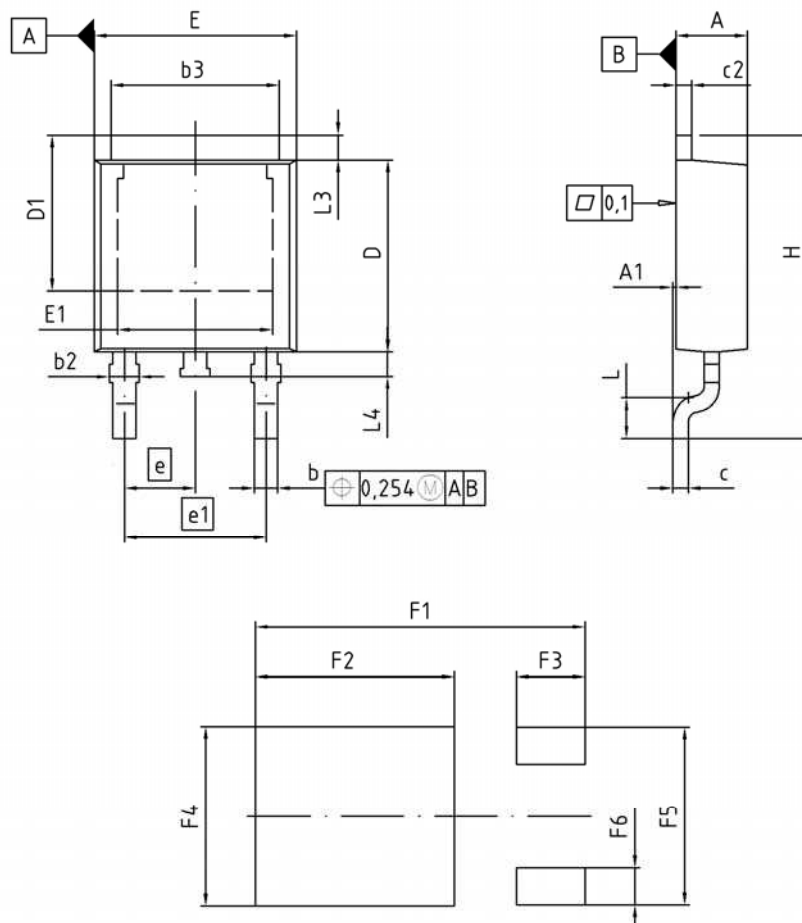
$$E_{oss}=f(V_{DS})$$



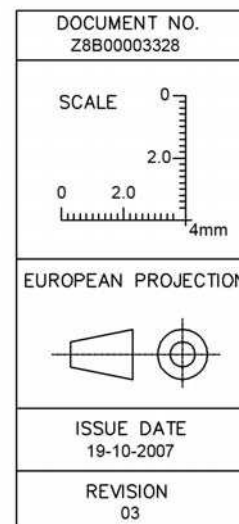
## Definition of diodes switching characteristics



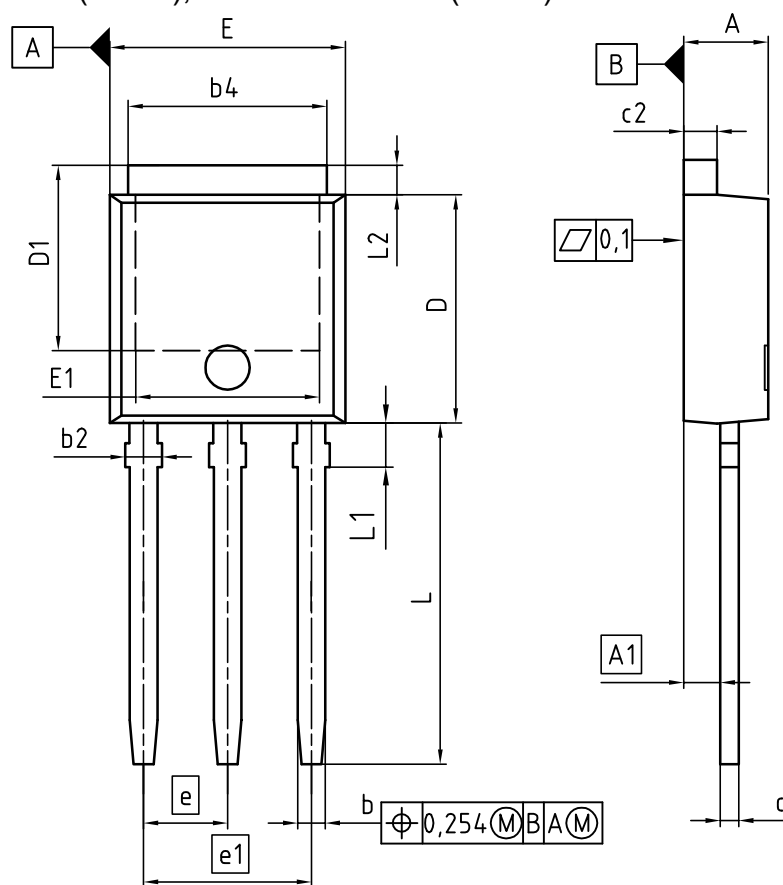
PG-TO-252-3-1 (D-PAK), PG-TO-252-3-11 (D-PAK), PG-TO-252-3-21 (D-PAK)



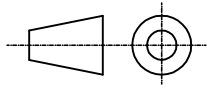
| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 2.16        | 2.41  | 0.085  | 0.095 |
| A1  | 0.00        | 0.15  | 0.000  | 0.006 |
| b   | 0.64        | 0.89  | 0.025  | 0.035 |
| b2  | 0.65        | 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 |



PG-TO-251-3-1 (I-PAK), PG-TO-251-3-21 (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 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NO.</b><br>Z8B00003330                                                                                  |
| <b>SCALE</b><br>0 2.0 4mm                                                                                           |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>19-03-2008                                                                                     |
| <b>REVISION</b><br>03                                                                                               |

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