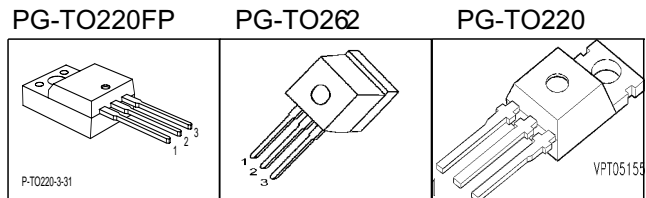


## Cool MOS™ Power Transistor

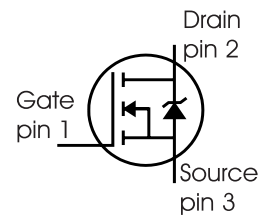
### Feature

- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- PG-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

|                     |      |          |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 650  | V        |
| $R_{DS(on)}$        | 0.19 | $\Omega$ |
| $I_D$               | 20.7 | A        |



| Type       | Package      | Ordering Code | Marking |
|------------|--------------|---------------|---------|
| SPP20N60C3 | PG-TO220     | Q67040-S4398  | 20N60C3 |
| SPI20N60C3 | PG-TO262-3-1 | Q67040-S4550  | 20N60C3 |
| SPA20N60C3 | PG-TO220FP   | SP000216354   | 20N60C3 |



### Maximum Ratings

| Parameter  | Symbol              | Value        |  | Unit             |
|--|---------------------|--------------|--|------------------|
|  |                     | SPP_I        | SPA                                      |                  |
| Continuous drain current<br>$T_C = 25\text{ }^\circ\text{C}$<br>$T_C = 100\text{ }^\circ\text{C}$                | $I_D$               | 20.7<br>13.1 | 20.7 <sup>1)</sup><br>13.1 <sup>1)</sup> | A                |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$  | $I_{D\text{ puls}}$ | 62.1         | 62.1                                     | A                |
| Avalanche energy, single pulse<br>$I_D=10\text{A}, V_{DD}=50\text{V}$  | $E_{AS}$            | 690          | 690                                      | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup><br>$I_D=20\text{A}, V_{DD}=50\text{V}$ | $E_{AR}$            | 1            | 1  |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$   | $I_{AR}$            | 20           | 20                                       | A                |
| Gate source voltage static   | $V_{GS}$            | $\pm 20$     | $\pm 20$                                 | V                |
| Gate source voltage AC ( $f > 1\text{Hz}$ )  | $V_{GS}$            | $\pm 30$     | $\pm 30$                                 |                  |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$  | $P_{tot}$           | 208          | 34.5                                     | W                |
| Operating and storage temperature  | $T_j, T_{stg}$      | -55...+150   |  | $^\circ\text{C}$ |
| Reverse diode $dv/dt$ <sup>7)</sup>  | $dv/dt$             | 15           |  | V/ns             |

### Maximum Ratings

| Parameter  | Symbol  | Value | Unit |
|--|---------|-------|------|
| Drain Source voltage slope<br>$V_{DS} = 480 \text{ V}, I_D = 20.7 \text{ A}, T_j = 125 \text{ }^\circ\text{C}$ | $dv/dt$ | 50    | V/ns |

### Thermal Characteristics

| Parameter   | Symbol                | Values |      |      | Unit |
|---|-----------------------|--------|------|------|------|
|   |                       | min.   | typ. | max. |      |
| Thermal resistance, junction - case   | $R_{thJC}$            | -      | -    | 0.6  | K/W  |
| Thermal resistance, junction - case, FullPAK  | $R_{thJC \text{ FP}}$ | -      | -    | 3.6  |      |
| Thermal resistance, junction - ambient, leaded  | $R_{thJA}$            | -      | -    | 62   |      |
| Thermal resistance, junction - ambient, FullPAK   | $R_{thJA \text{ FP}}$ | -      | -    | 80   |      |
| SMD version, device on PCB:<br>@ min. footprint<br>@ 6 cm <sup>2</sup> cooling area <sup>3)</sup> | $R_{thJA}$            | -      | -    | 62   |      |
| Soldering temperature, wavesoldering<br>1.6 mm (0.063 in.) from case for 10s <sup>4)</sup>        | $T_{sold}$            | -      | -    | 260  | °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 | $V_{(BR)DS}$  | $V_{GS}=0\text{V}, I_D=20\text{A}$   | -      | 700  | -    |               |
| Gate threshold voltage                   | $V_{GS(th)}$  | $I_D=1000\mu\text{A}, V_{GS}=V_{DS}$   | 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>$T_j=150^\circ\text{C}$ | -      | 0.1  | 1    | $\mu\text{A}$ |
| Gate-source leakage current              | $I_{GSS}$     | $V_{GS}=30\text{V}, V_{DS}=0\text{V}$  | -      | -    | 100  |               |
| Drain-source on-state resistance         | $R_{DS(on)}$  | $V_{GS}=10\text{V}, I_D=13.1\text{A}$<br>$T_j=25^\circ\text{C}$<br>$T_j=150^\circ\text{C}$   | -      | 0.16 | 0.19 | $\Omega$      |
| Gate input resistance                    | $R_G$         | $f=1\text{MHz}, \text{open drain}$   | -      | 0.54 | -    |               |

### Electrical Characteristics

| Parameter   | Symbol       | Conditions   | Values |      |      | Unit |
|---|--------------|--|--------|------|------|------|
|   |              |  | min.   | typ. | max. |      |
| Transconductance  | $g_{fs}$     | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ ,<br>$I_D = 13.1A$                                   | -      | 17.5 | -    | S    |
| Input capacitance   | $C_{iss}$    | $V_{GS} = 0V$ , $V_{DS} = 25V$ ,   | -      | 2400 | -    | pF   |
| Output capacitance  | $C_{oss}$    | $f = 1MHz$   | -      | 780  | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |  | -      | 50   | -    |      |
| Effective output capacitance, <sup>5)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0V$ ,<br>$V_{DS} = 0V$ to 480V   | -      | 83   | -    |      |
| Effective output capacitance, <sup>6)</sup><br>time related   | $C_{o(tr)}$  |  | -      | 160  | -    |      |
| Turn-on delay time  | $t_{d(on)}$  | $V_{DD} = 380V$ , $V_{GS} = 0/13V$ ,<br>$I_D = 20.7A$ ,<br>$R_G = 3.6\Omega$ , $T_J = 125^\circ C$ | -      | 10   | -    | ns   |
| Rise time   | $t_r$        |  | -      | 5    | -    |      |
| Turn-off delay time   | $t_{d(off)}$ |  | -      | 67   | 100  |      |
| Fall time   | $t_f$        |  | -      | 4.5  | 12   |      |

### Gate Charge Characteristics

|                       |                 |  |   |     |     |    |
|-----------------------|-----------------|--|---|-----|-----|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 480V$ , $I_D = 20.7A$                          | - | 11  | -   | nC |
| Gate to drain charge  | $Q_{gd}$        |  | - | 33  | -   |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 480V$ , $I_D = 20.7A$ ,<br>$V_{GS} = 0$ to 10V | - | 87  | 114 |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 480V$ , $I_D = 20.7A$                          | - | 5.5 | -   | V  |

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

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

<sup>1</sup>Limited only by maximum temperature

<sup>2</sup>Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV} = E_{AR} \cdot f$ .

<sup>3</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>4</sup>Soldering temperature for TO-263: 220°C, reflow

<sup>5</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>6</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%  $V_{DSS}$ .

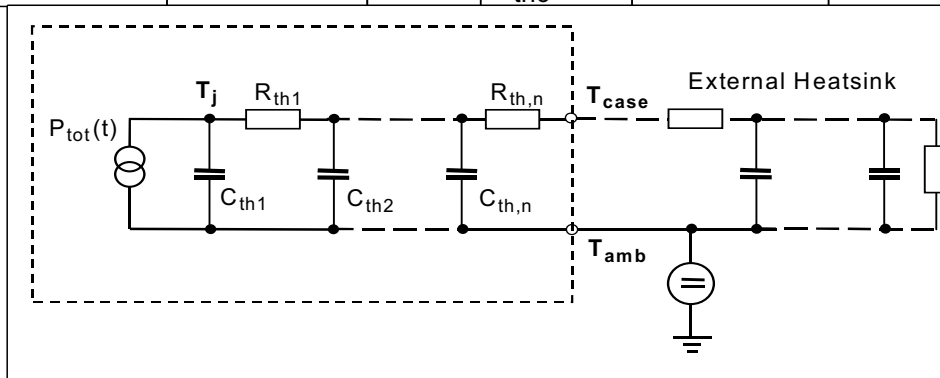
<sup>7</sup> $I_{SD} \leq I_D$ ,  $di/dt \leq 400A/\mu s$ ,  $V_{DClink} = 400V$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_J < T_{J,max}$ . Identical low-side and high-side switch.

**Electrical Characteristics**

| Parameter                                     | Symbol       | Conditions                        | Values |      |      | Unit                   |
|---|--------------|-----------------------------------|--------|------|------|------------------------|
|   |              |                                   | min.   | typ. | max. |                        |
| Inverse diode continuous forward current      | $I_S$        | $T_C=25^\circ\text{C}$            | -      | -    | 20.7 | A                      |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                   | -      | -    | 62.1 |                        |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0\text{V}, I_F=I_S$       | -      | 1    | 1.2  | V                      |
| Reverse recovery time                         | $t_{rr}$     | $V_R=480\text{V}, I_F=I_S,$       | -      | 500  | 800  | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     | $di_F/dt=100\text{A}/\mu\text{s}$ | -      | 11   | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                   | -      | 70   | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ | $T_j=25^\circ\text{C}$            | -      | 1400 | -    | $\text{A}/\mu\text{s}$ |

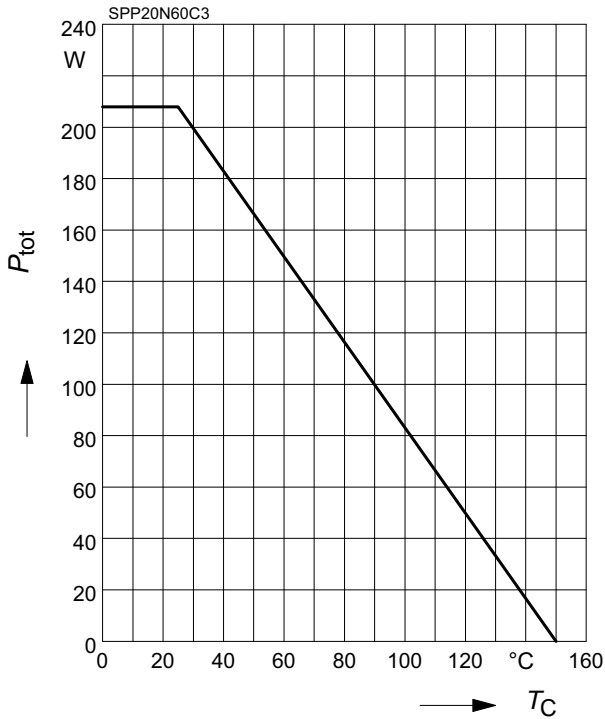
**Typical Transient Thermal Characteristics**

| Symbol    | Value   |         | Unit | Symbol    | Value     |           | Unit |
|-----------|---------|---------|------|-----------|-----------|-----------|------|
|           | SPP_I   | SPA     |      |           | SPP_I     | SPA       |      |
| $R_{th1}$ | 0.00769 | 0.00769 | K/W  | $C_{th1}$ | 0.0003763 | 0.0003763 | Ws/K |
| $R_{th2}$ | 0.015   | 0.015   |      | $C_{th2}$ | 0.001411  | 0.001411  |      |
| $R_{th3}$ | 0.029   | 0.029   |      | $C_{th3}$ | 0.001931  | 0.001931  |      |
| $R_{th4}$ | 0.114   | 0.163   |      | $C_{th4}$ | 0.005297  | 0.005297  |      |
| $R_{th5}$ | 0.136   | 0.323   |      | $C_{th5}$ | 0.012     | 0.008453  |      |
| $R_{th6}$ | 0.059   | 2.526   |      | $C_{th6}$ | 0.091     | 0.412     |      |



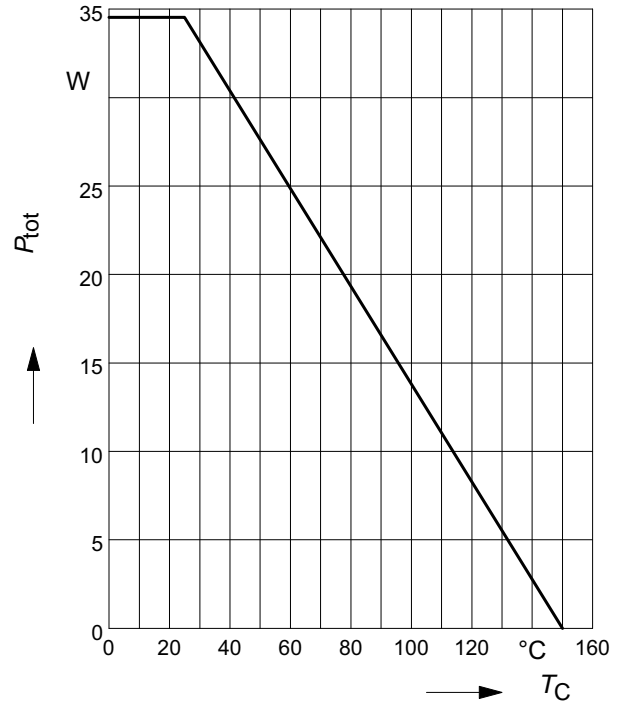
### 1 Power dissipation

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



### 2 Power dissipation FullPAK

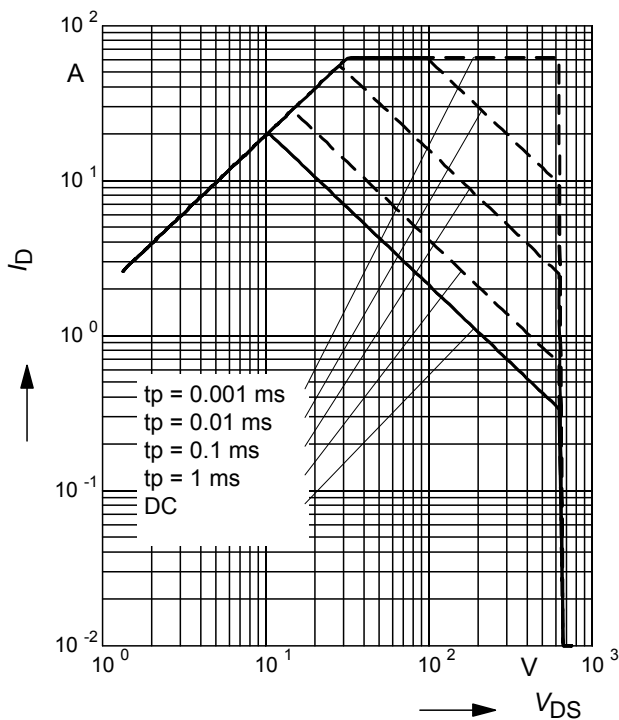
$$P_{tot} = f(T_C)$$



### 3 Safe operating area

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

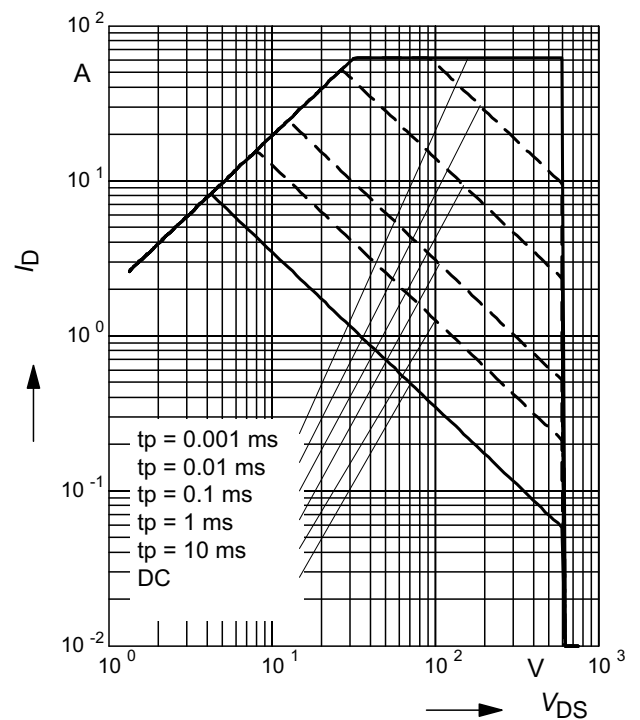
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 4 Safe operating area FullPAK

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

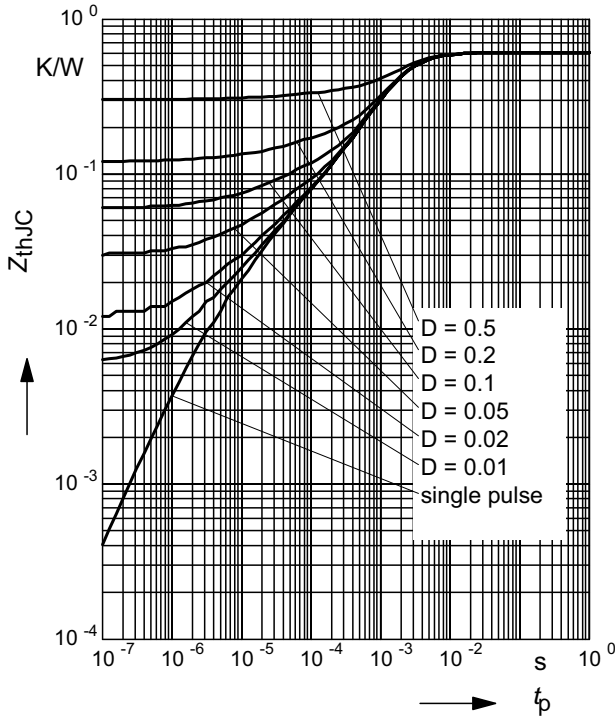
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

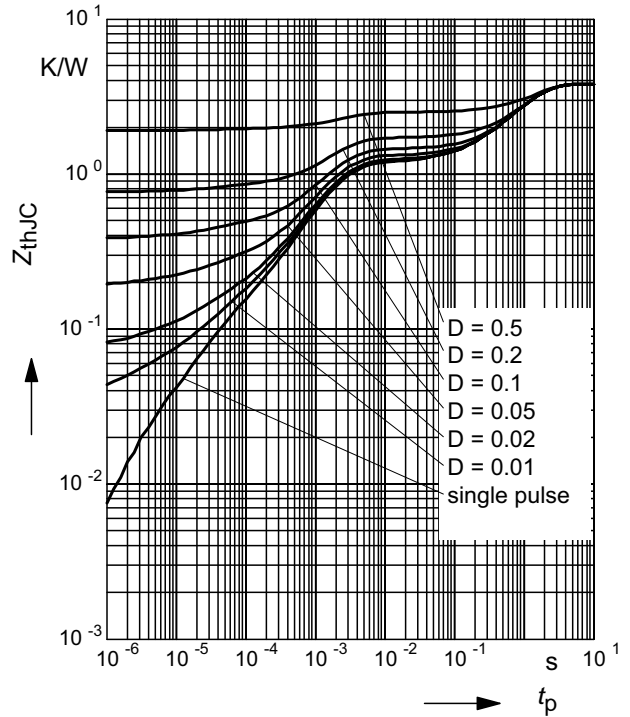
parameter:  $D = t_p/T$



**6 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

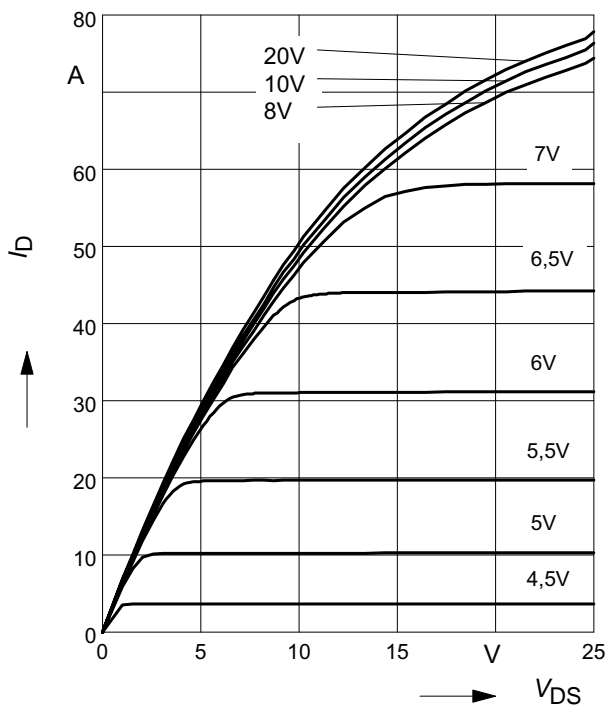
parameter:  $D = t_p/t$



**7 Typ. output characteristic**

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

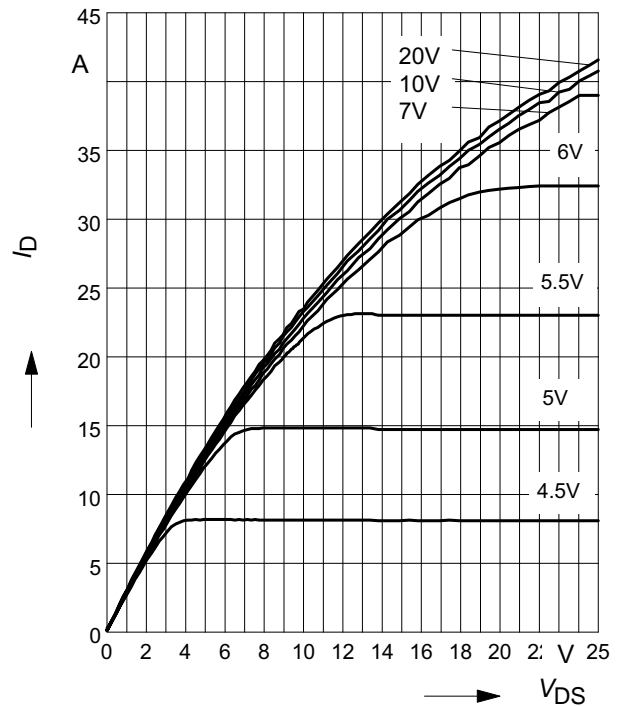
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**8 Typ. output characteristic**

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

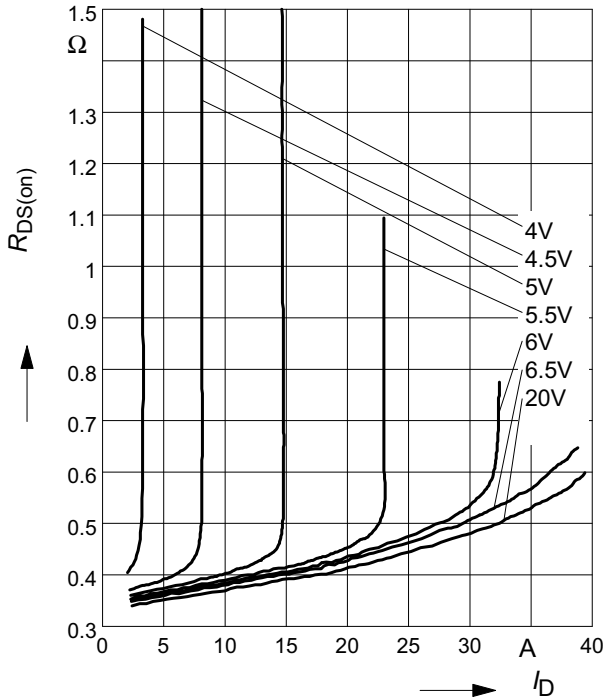
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

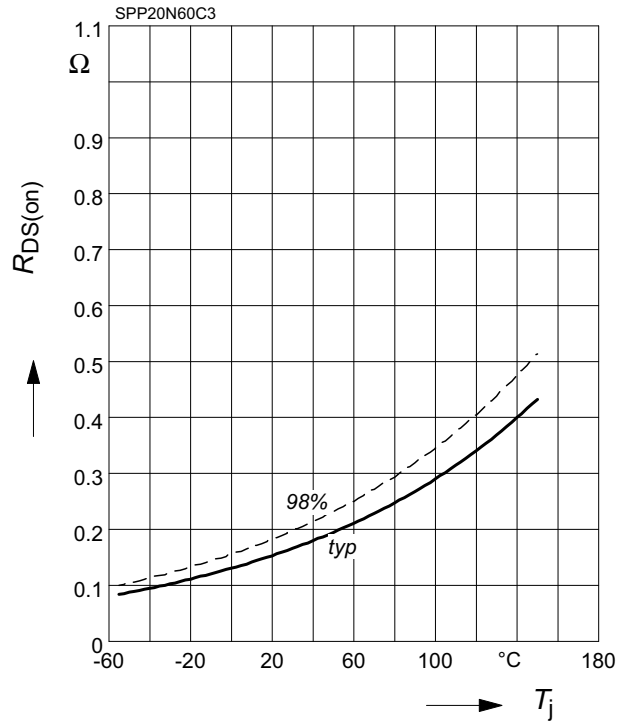
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



**10 Drain-source on-state resistance**

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

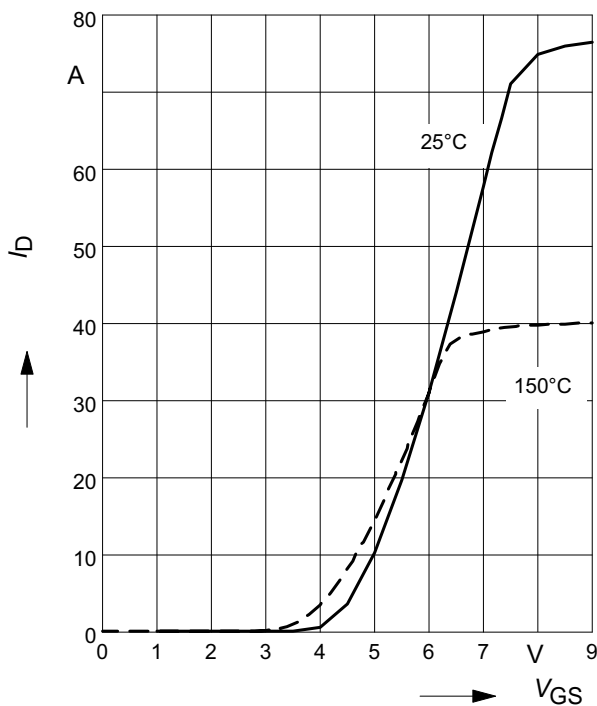
parameter:  $I_D = 13.1\text{ A}$ ,  $V_{GS} = 10\text{ V}$



**11 Typ. transfer characteristics**

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

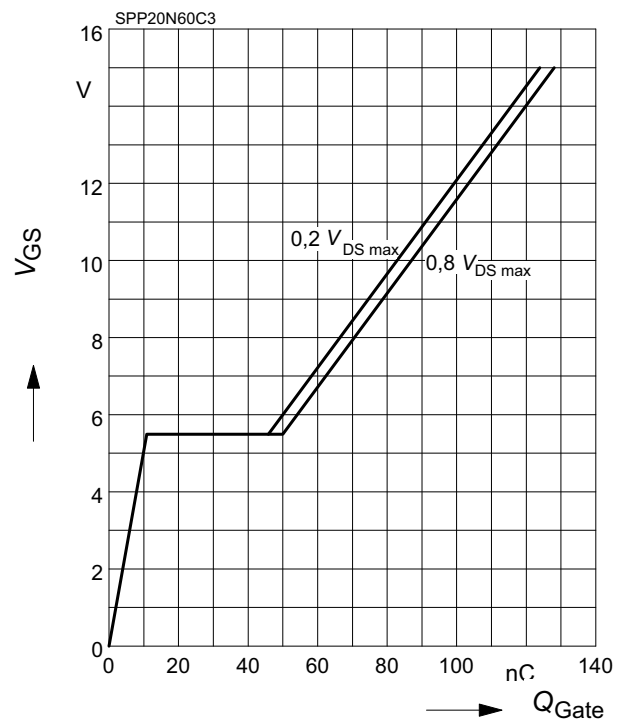
parameter:  $t_p = 10\ \mu\text{s}$



**12 Typ. gate charge**

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

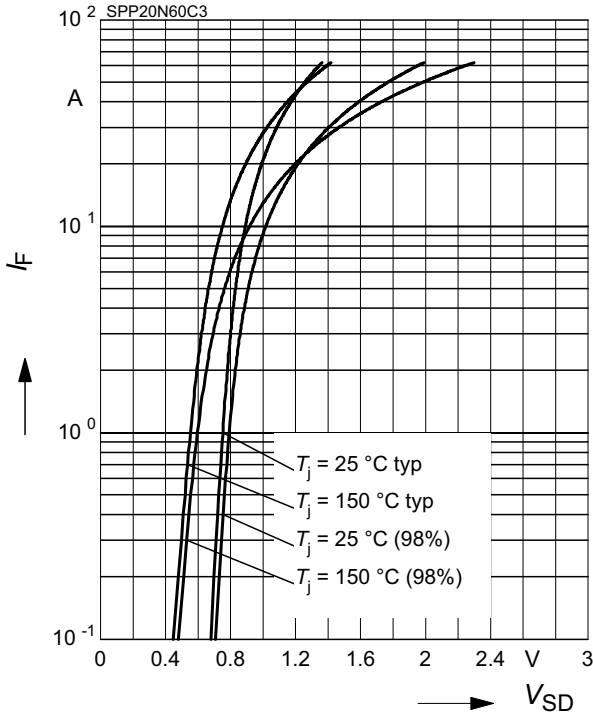
parameter:  $I_D = 20.7\text{ A pulsed}$



**13 Forward characteristics of body diode**

$I_F = f(V_{SD})$

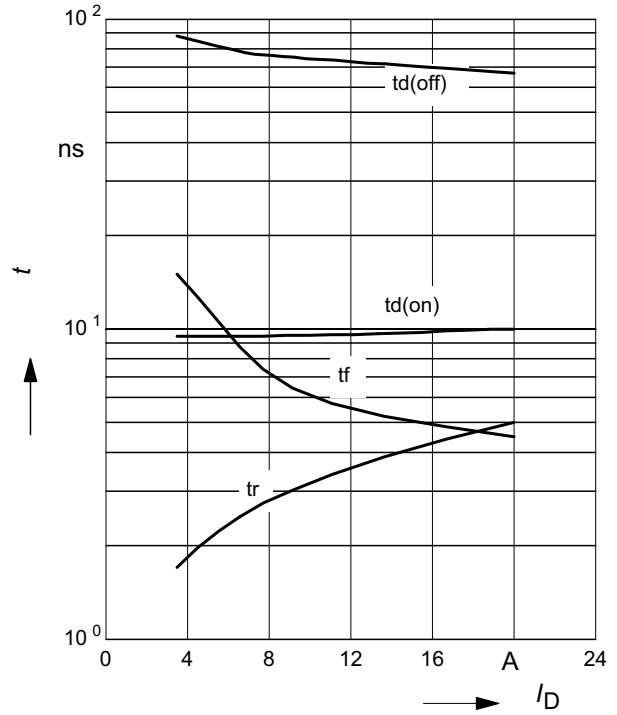
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Typ. switching time**

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

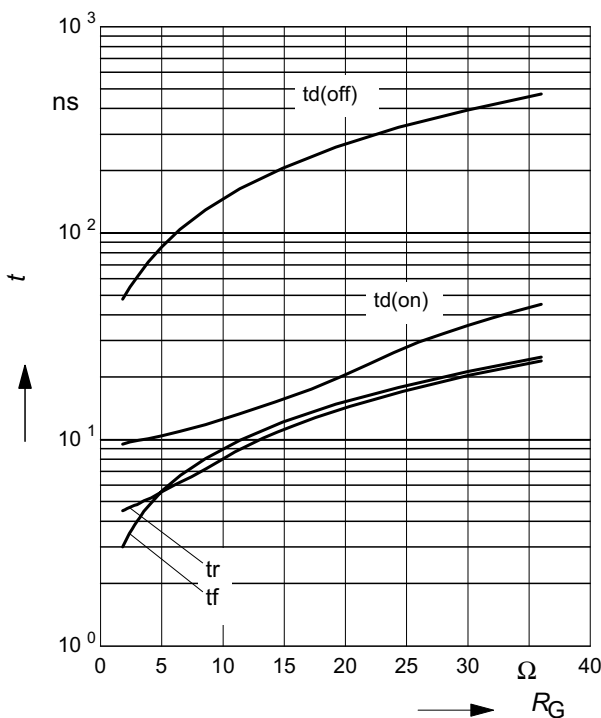
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $R_G = 3.6\Omega$



**15 Typ. switching time**

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

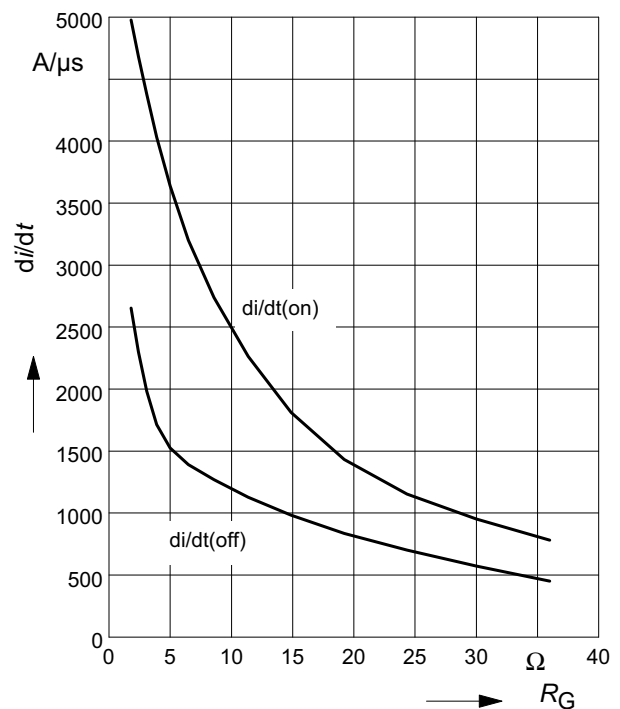
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 20.7 A$



**16 Typ. drain current slope**

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

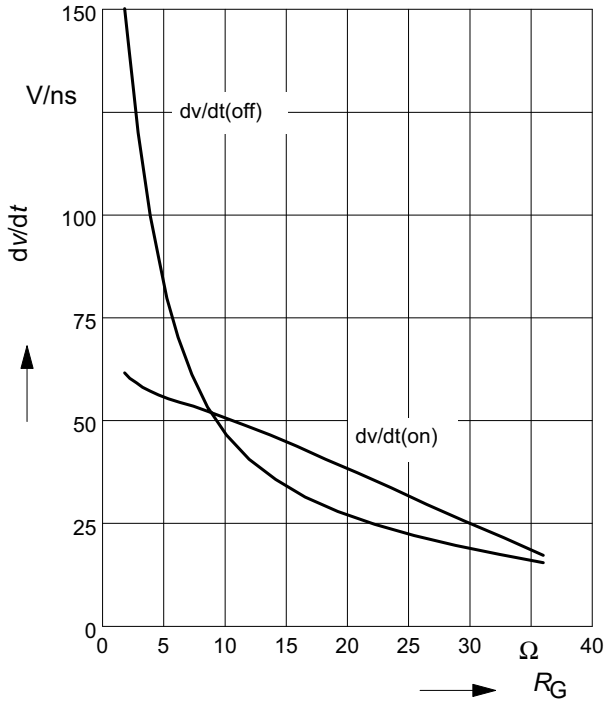
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 20.7A$





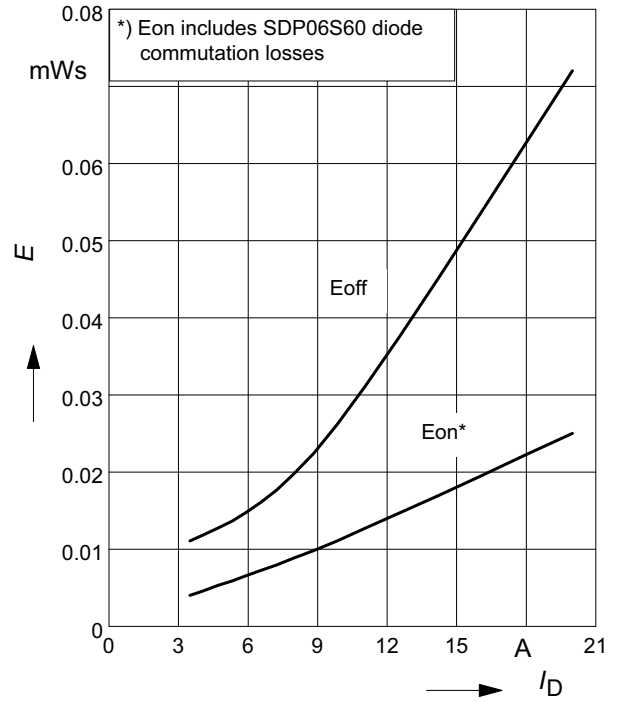
**17 Typ. drain source voltage slope**

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=20.7\text{A}$



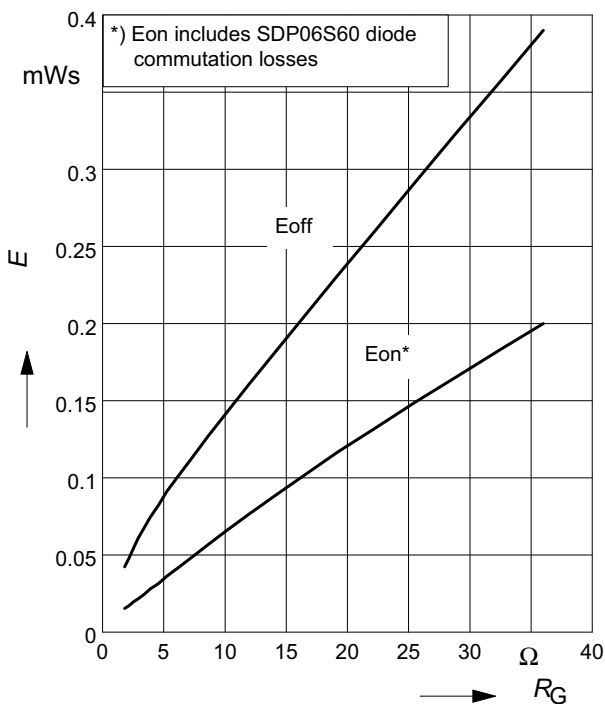
**18 Typ. switching losses**

$E = f(I_D)$ , inductive load,  $T_j=125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=3.6\Omega$



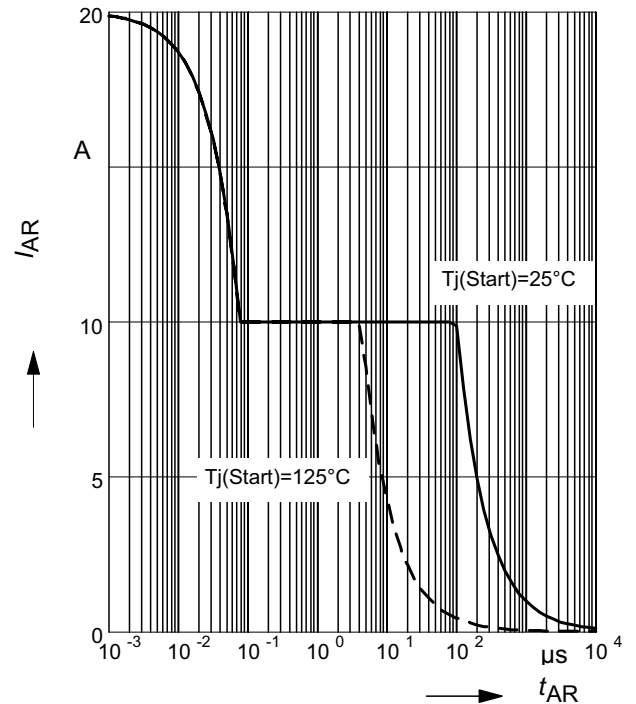
**19 Typ. switching losses**

$E = f(R_G)$ , inductive load,  $T_j=125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=20.7\text{A}$



**20 Avalanche SOA**

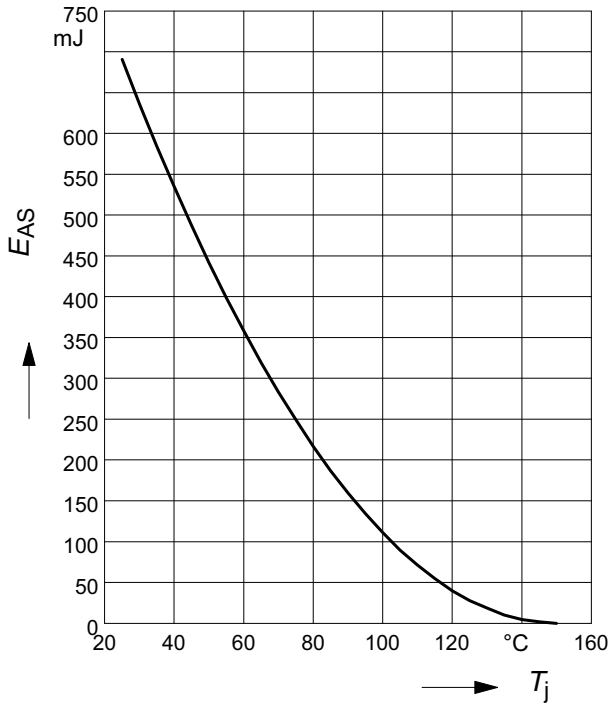
$I_{AR} = f(t_{AR})$   
 par.:  $T_j \leq 150^\circ\text{C}$



**21 Avalanche energy**

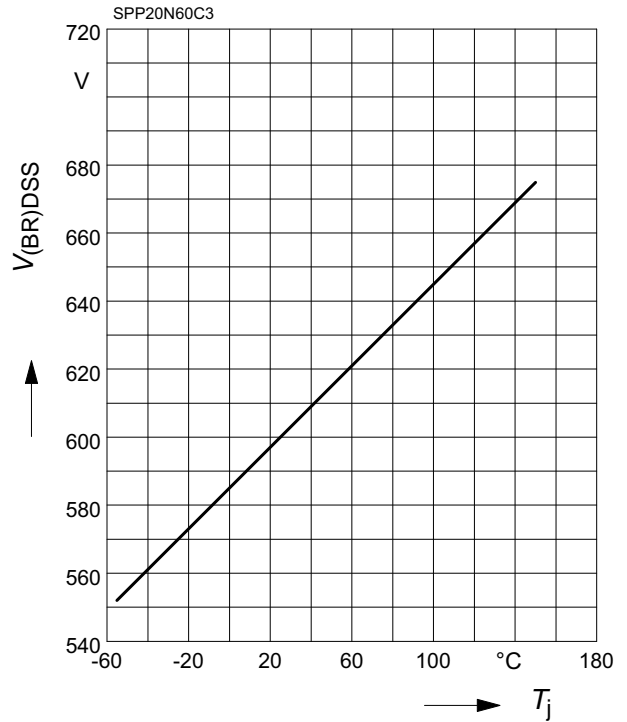
$E_{AS} = f(T_j)$

par.:  $I_D = 10\text{ A}$ ,  $V_{DD} = 50\text{ V}$



**22 Drain-source breakdown voltage**

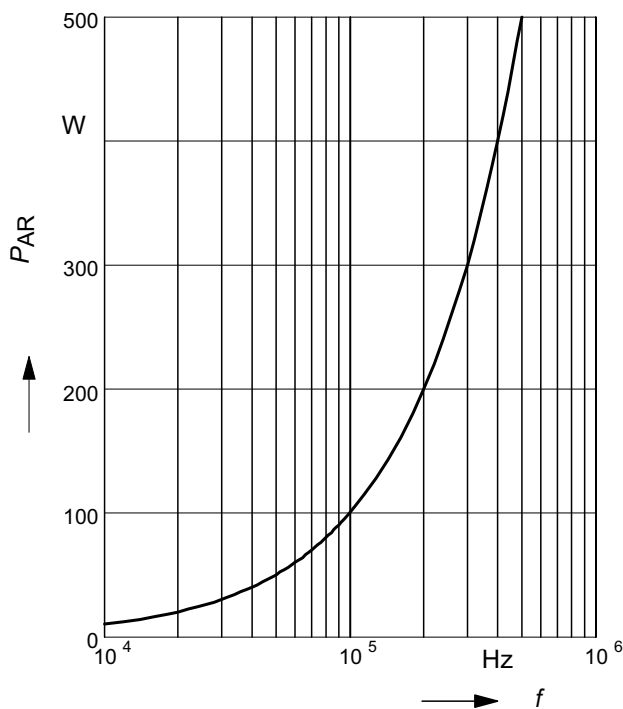
$V_{(BR)DSS} = f(T_j)$



**23 Avalanche power losses**

$P_{AR} = f(f)$

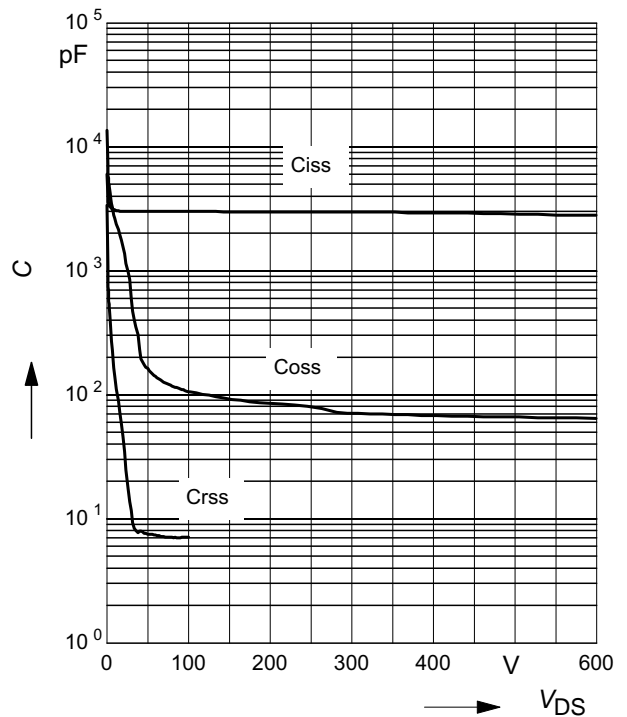
parameter:  $E_{AR} = 1\text{ mJ}$



**24 Typ. capacitances**

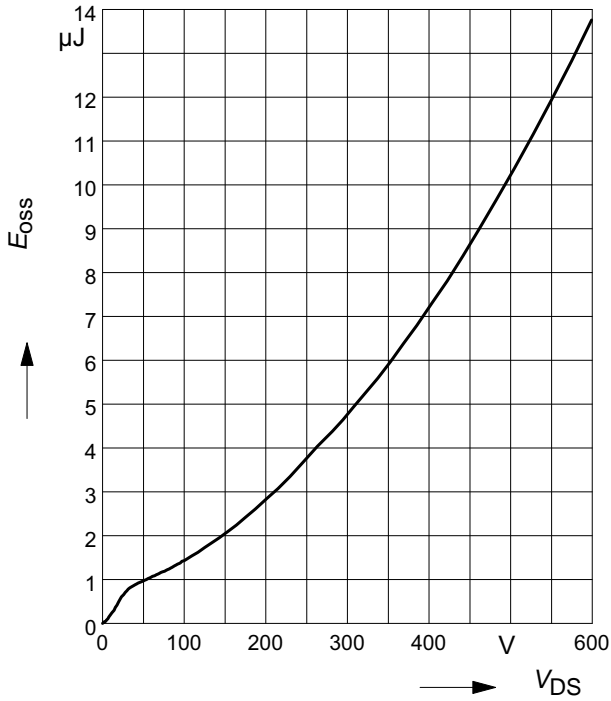
$C = f(V_{DS})$

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

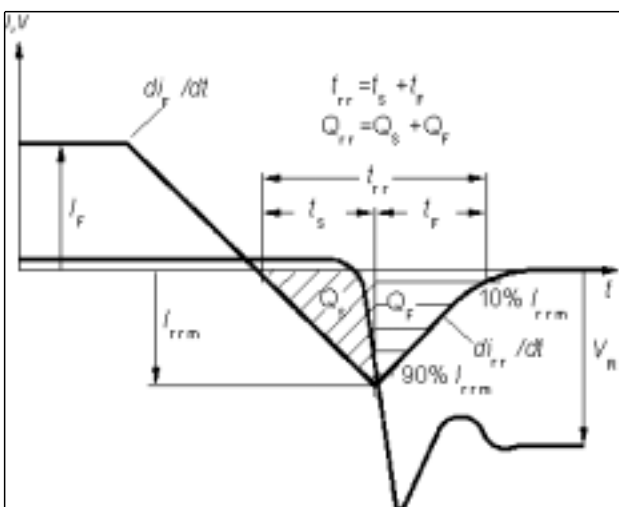


25 Typ.  $C_{oss}$  stored energy

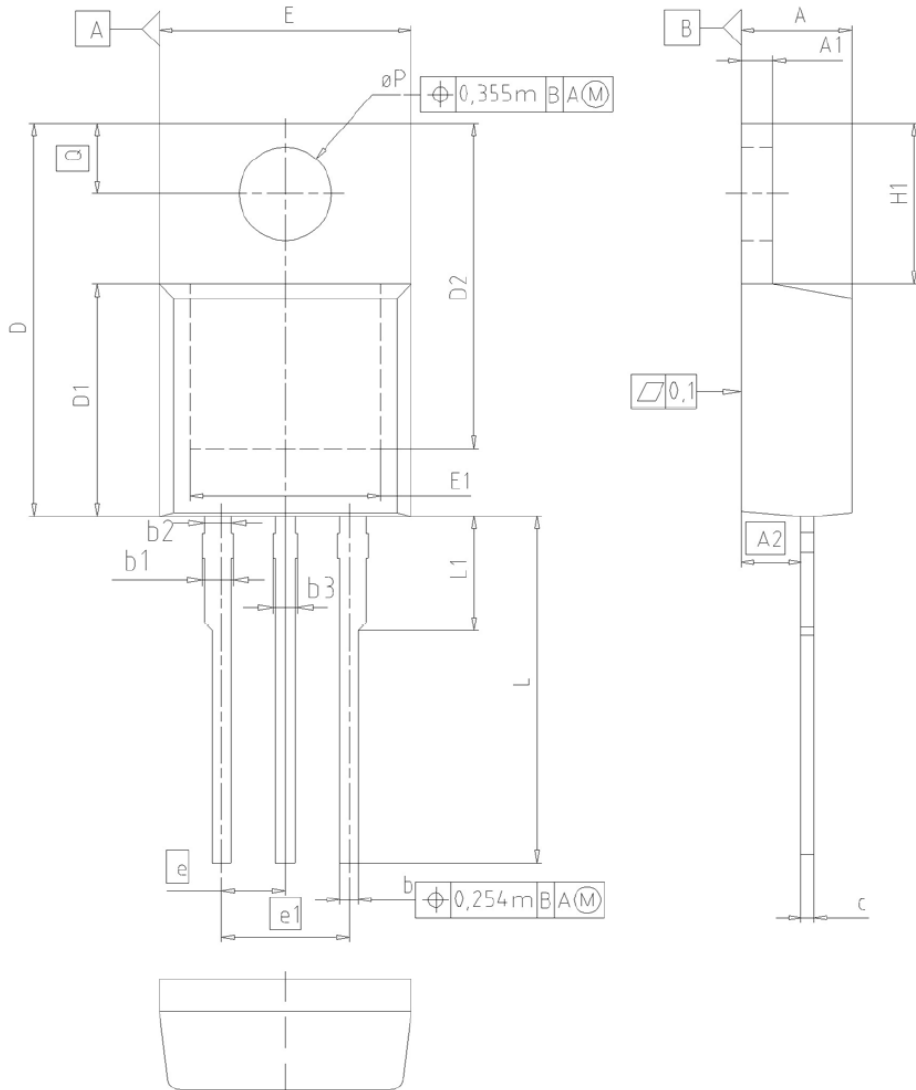
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics



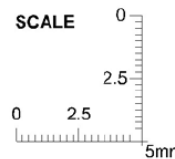
PG-TO220-3-1, PG-TO220-3-21 : Outline




| DIM      | MILLIMETERS |       | INCHES |       |
|----------|-------------|-------|--------|-------|
|          | MIN         | MAX   | MIN    | MAX   |
| A        | 4.30        | 4.57  | 0.169  | 0.180 |
| A1       | 1.17        | 1.40  | 0.046  | 0.055 |
| A2       | 2.15        | 2.72  | 0.085  | 0.107 |
| b        | 0.65        | 0.86  | 0.026  | 0.034 |
| b1       | 0.95        | 1.40  | 0.037  | 0.055 |
| b2       | 0.95        | 1.15  | 0.037  | 0.045 |
| b3       | 0.65        | 1.15  | 0.026  | 0.045 |
| c        | 0.33        | 0.60  | 0.013  | 0.024 |
| D        | 14.81       | 15.95 | 0.583  | 0.628 |
| D1       | 8.51        | 9.45  | 0.335  | 0.372 |
| D2       | 12.19       | 13.10 | 0.480  | 0.516 |
| E        | 9.70        | 10.36 | 0.382  | 0.408 |
| E1       | 6.50        | 8.60  | 0.256  | 0.339 |
| e        | 2.54        |       | 0.100  |       |
| e1       | 5.08        |       | 0.200  |       |
| N        | 3           |       | 3      |       |
| H1       | 5.90        | 6.90  | 0.232  | 0.272 |
| L        | 13.00       | 14.00 | 0.512  | 0.551 |
| L1       | -           | 4.80  | -      | 0.189 |
| $\phi P$ | 3.60        | 3.89  | 0.142  | 0.153 |
| Q        | 2.60        | 3.00  | 0.102  | 0.118 |

**DOCUMENT NO.**  
Z8B0003318

**SCALE**



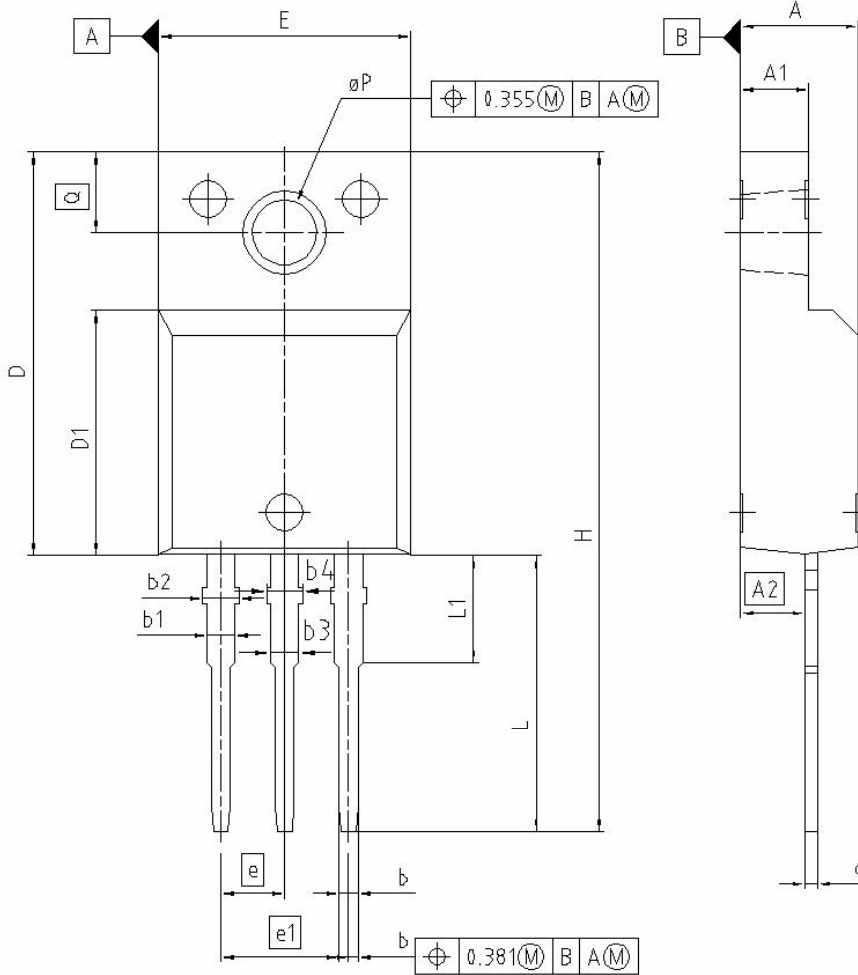
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**ISSUE DATE**  
23-08-2007

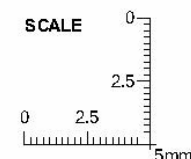
**REVISION**  
05

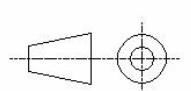
PG-TO220-3-31/-3-111 Fully isolated package ( 2500 VAC; 1 minute )



| DIM      | MILLIMETERS |       | INCHES |       |
|----------|-------------|-------|--------|-------|
|          | MIN         | MAX   | MIN    | MAX   |
| A        | 4.55        | 4.85  | 0.179  | 0.191 |
| A1       | 2.55        | 2.85  | 0.100  | 0.112 |
| A2       | 2.42        | 2.72  | 0.095  | 0.107 |
| b        | 0.65        | 0.85  | 0.026  | 0.033 |
| b1       | 0.95        | 1.33  | 0.037  | 0.052 |
| b2       | 0.95        | 1.51  | 0.037  | 0.059 |
| b3       | 0.65        | 1.33  | 0.026  | 0.052 |
| b4       | 0.65        | 1.51  | 0.026  | 0.059 |
| c        | 0.40        | 0.63  | 0.016  | 0.025 |
| D        | 15.85       | 16.15 | 0.624  | 0.636 |
| D1       | 9.53        | 9.83  | 0.375  | 0.387 |
| E        | 10.35       | 10.65 | 0.407  | 0.419 |
| e        | 2.54        |       | 0.100  |       |
| e1       | 5.08        |       | 0.200  |       |
| N        | 3           |       | 3      |       |
| H        | 29.45       | 29.75 | 1.159  | 1.171 |
| L        | 13.45       | 13.75 | 0.530  | 0.541 |
| L1       | 3.15        | 3.45  | 0.124  | 0.136 |
| $\phi P$ | 2.95        | 3.20  | 0.116  | 0.126 |
| Q        | 3.15        | 3.50  | 0.124  | 0.138 |

REFERENCE  
*./..*

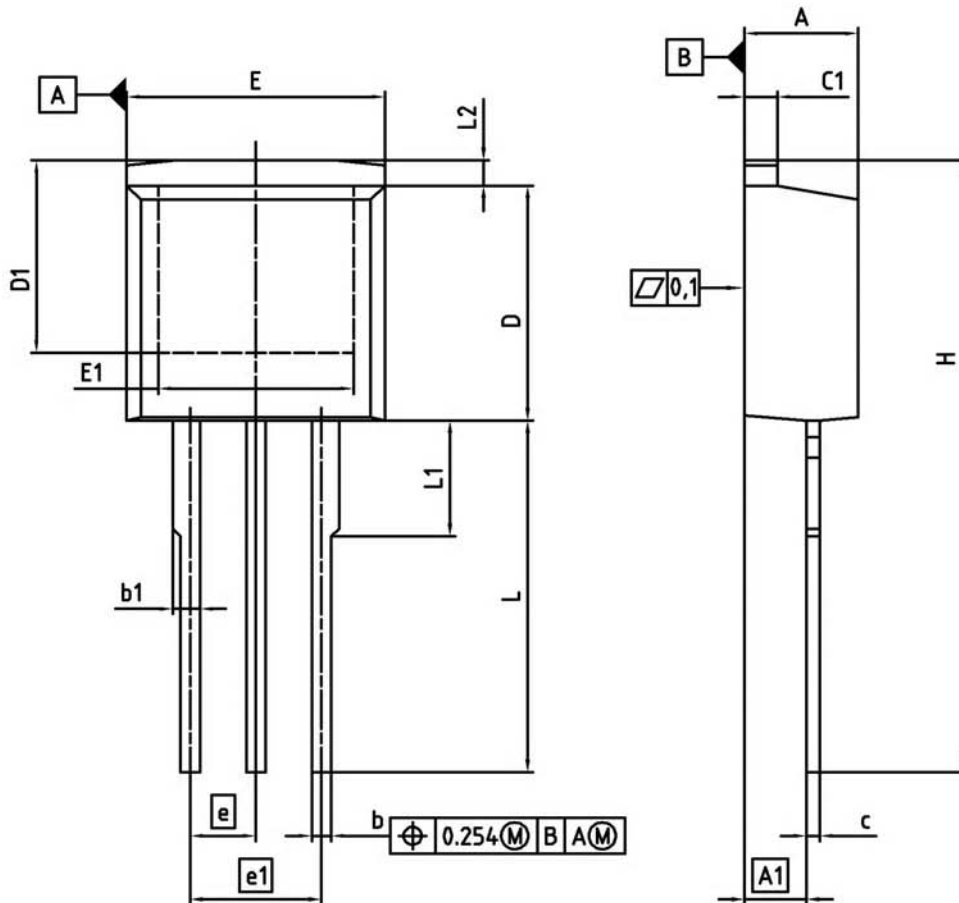
SCALE  


EUROPEAN PROJECTION  


ISSUE DATE  
 08-01-2007

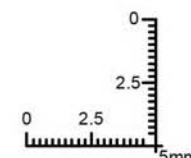
FILE  
 TO220\_2

PG-TO262-3-1/PG-TO262-3-21 (I<sup>2</sup>-PAK)

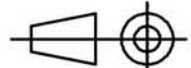


| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 4.300       | 4.572  | 0.169  | 0.180 |
| A1  | 2.150       | 2.718  | 0.085  | 0.107 |
| b   | 0.650       | 0.864  | 0.026  | 0.034 |
| b1  | 0.635       | 1.400  | 0.025  | 0.055 |
| c   | 0.330       | 0.600  | 0.013  | 0.024 |
| c1  | 1.170       | 1.400  | 0.046  | 0.055 |
| D   | 8.509       | 9.450  | 0.335  | 0.372 |
| D1  | 6.900       | -      | 0.272  | -     |
| E   | 9.700       | 10.363 | 0.382  | 0.408 |
| E1  | 6.500       | 8.600  | 0.256  | 0.339 |
| e   | 2.540       |        | 0.100  |       |
| e1  | 5.080       |        | 0.200  |       |
| N   | 3           |        | 3      |       |
| L   | 13.000      | 14.000 | 0.512  | 0.551 |
| L1  | -           | 4.800  | -      | 0.189 |
| L2  | -           | 1.727  | -      | 0.068 |

REFERENCE  
JEDEC TO262



EUROPEAN PROJECTION



ISSUE DATE  
05-05-2006

FILE  
TO262\_1

**Published by**  
**Infineon Technologies AG**  
**81726 München**  
**Germany**

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