

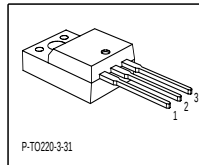
## Cool MOS™ Power Transistor

### Feature

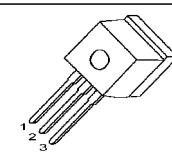
- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- PG-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)
- Pb-free lead plating; 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        |

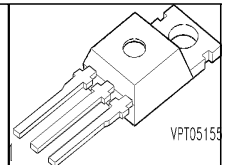
PG-TO220FP



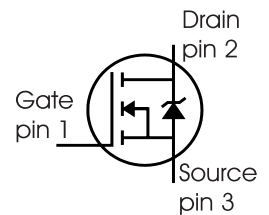
PG-TO262



PG-TO220



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



### Maximum Ratings

| Parameter                                                                                                           | Symbol               | Value        |                                          | Unit             |
|---------------------------------------------------------------------------------------------------------------------|----------------------|--------------|------------------------------------------|------------------|
|                                                                                                                     |                      | SPP_I        | SPA                                      |                  |
| Continuous drain current<br>$T_C = 25^\circ\text{C}$<br>$T_C = 100^\circ\text{C}$                                   | $I_D$                | 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, $T_C = 25^\circ\text{C}$                                                                         | $P_{tot}$            | 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>$V_{DS} = 480 \text{ V}$ , $I_D = 20.7 \text{ A}$ , $T_j = 125^\circ\text{C}$ | $dv/dt$ | 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> | $R_{thJA}$            | -<br>- | -<br>35 | 62<br>- | °C   |
| Soldering temperature, wavesoldering<br>1.6 mm (0.063 in.) from case for 10s <sup>4)</sup>        | $T_{sold}$            | -      | -       | 260     |      |

**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>$T_j = 25^\circ\text{C}$ | -      | 0.1  | 1    | $\mu\text{A}$ |
|                                          |               | $T_j = 150^\circ\text{C}$                                                   | -      | -    | 100  |               |
| Gate-source leakage current              | $I_{GSS}$     | $V_{GS} = 30\text{V}$ , $V_{DS} = 0\text{V}$                                | -      | -    | 100  | nA            |
| Drain-source on-state resistance         | $R_{DS(on)}$  | $V_{GS} = 10\text{V}$ , $I_D = 13.1\text{A}$<br>$T_j = 25^\circ\text{C}$    | -      | 0.16 | 0.19 | $\Omega$      |
|                                          |               | $T_j = 150^\circ\text{C}$                                                   | -      | 0.43 | -    |               |
|                                          |               | $f = 1\text{MHz}$ , open drain                                              | -      | 0.54 | -    |               |
| Gate input resistance                    | $R_G$         | $f = 1\text{MHz}$ , 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                                             | $C_{iss}$    | $V_{GS} = 0V$ , $V_{DS} = 25V$ ,<br>$f = 1MHz$                                                     | -      | 2400 | -    | pF   |
| Output capacitance                                            | $C_{oss}$    |                                                                                                    | -      | 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>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%  $V_{DSS}$ .

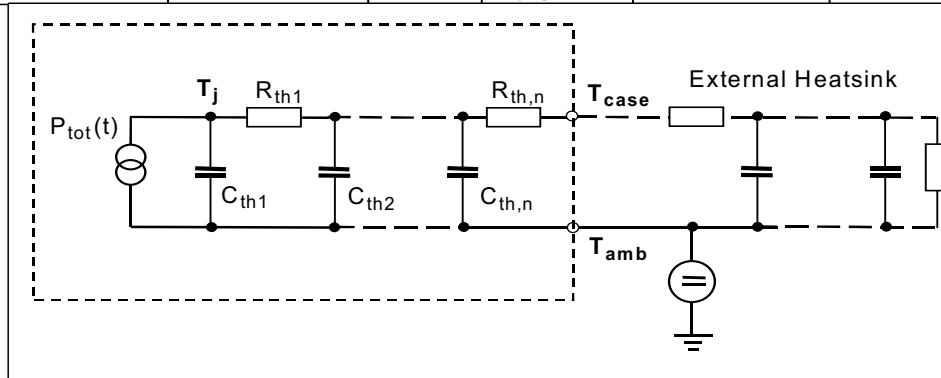
<sup>7</sup> $I_{SD} \leq I_D$ ,  $di/dt \leq 400A/\mu s$ ,  $V_{DClink} = 400V$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_J < T_{J,max}$ . Identical low-side and high-side switch.

### 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 | -    | $\text{A}/\mu\text{s}$ |

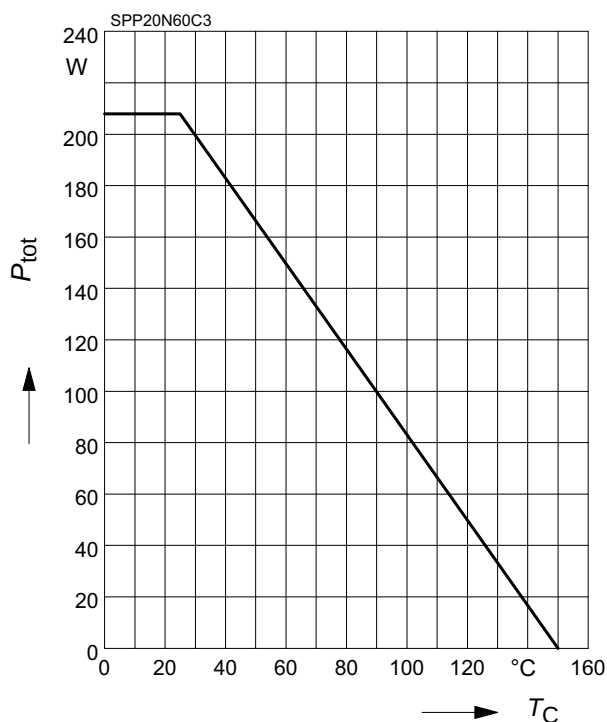
### Typical Transient Thermal Characteristics

| 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     |      |



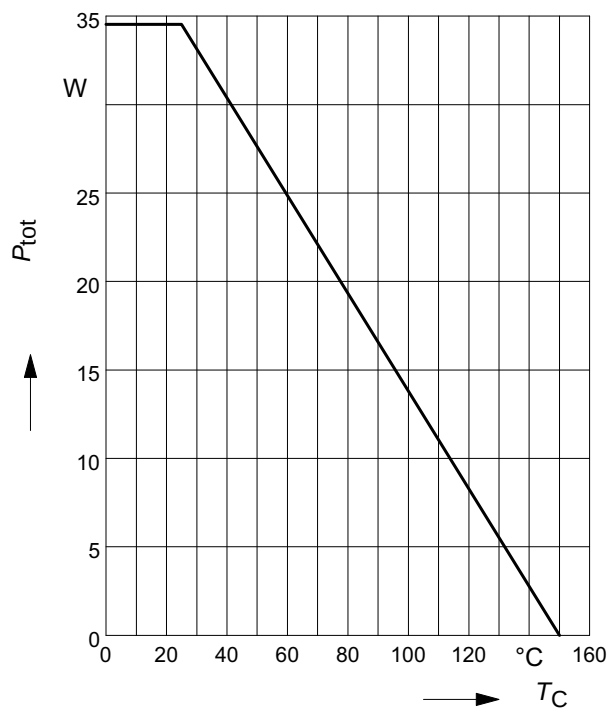
### 1 Power dissipation

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



### 2 Power dissipation FullPAK

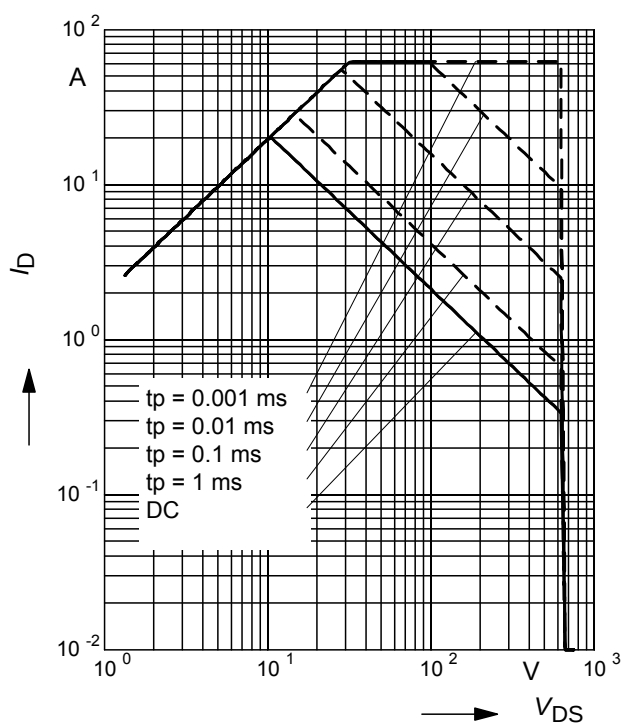
$$P_{\text{tot}} = f(T_C)$$



### 3 Safe operating area

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

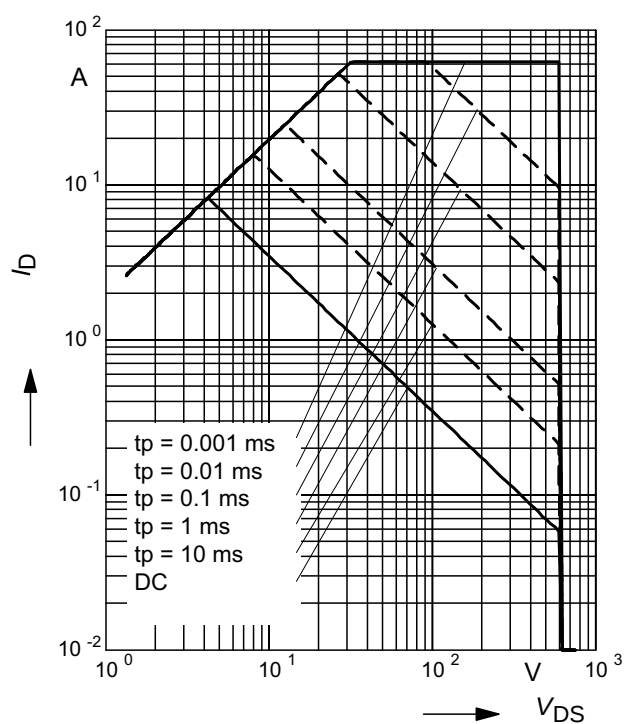
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 4 Safe operating area FullPAK

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

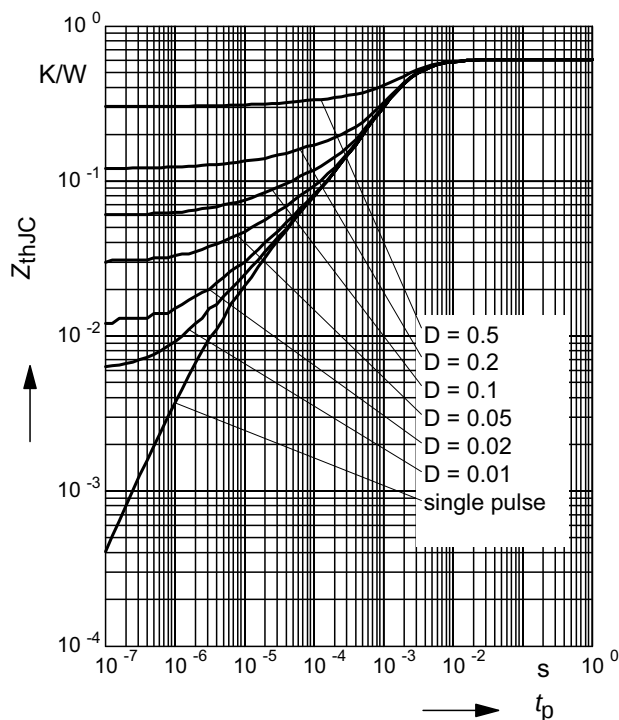
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



## 5 Transient thermal impedance

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

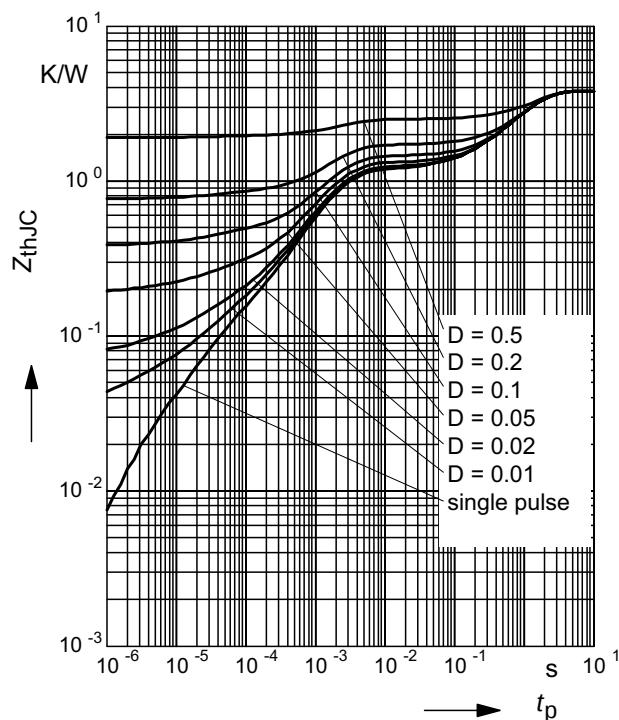
parameter:  $D = t_p/T$



## 6 Transient thermal impedance FullPAK

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

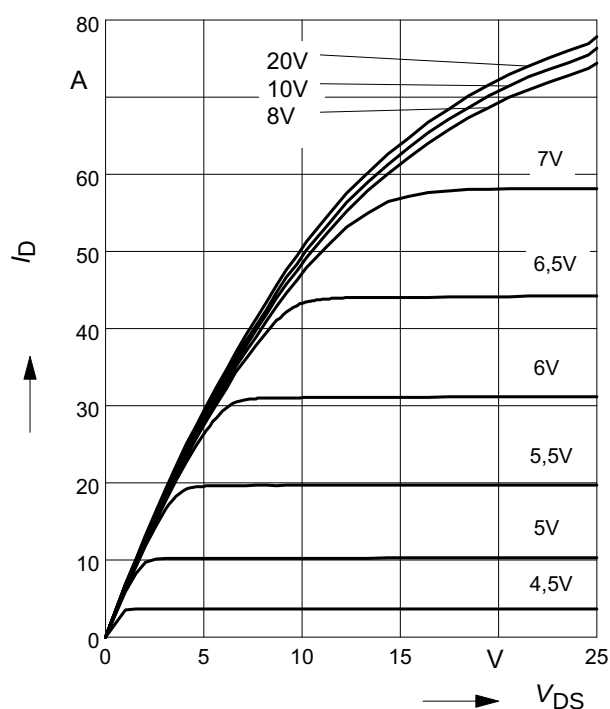
parameter:  $D = t_p/t$



## 7 Typ. output characteristic

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

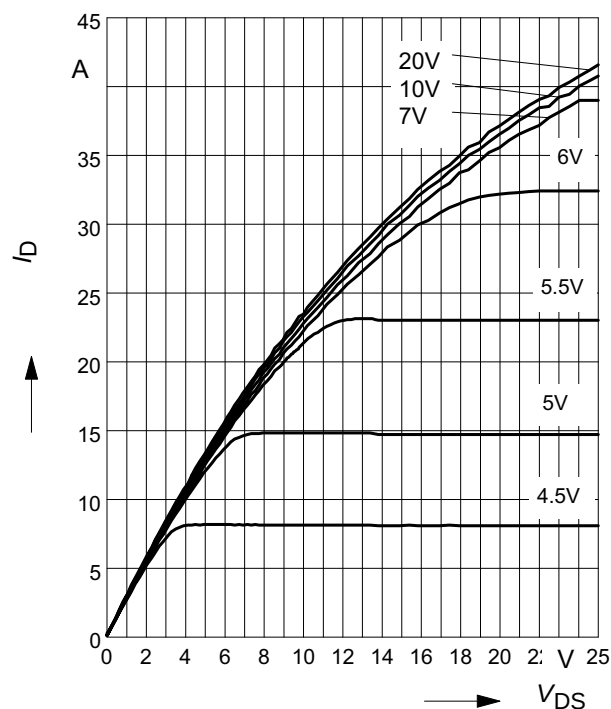
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



## 8 Typ. output characteristic

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

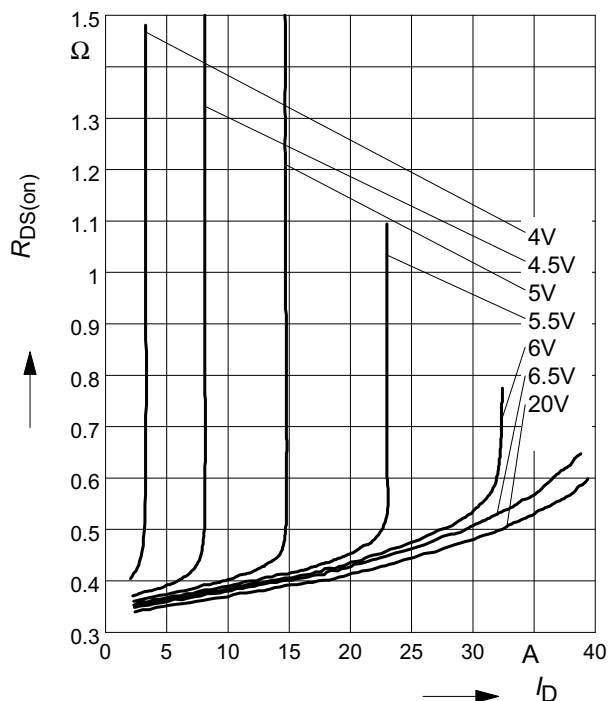
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



### 9 Typ. drain-source on resistance

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

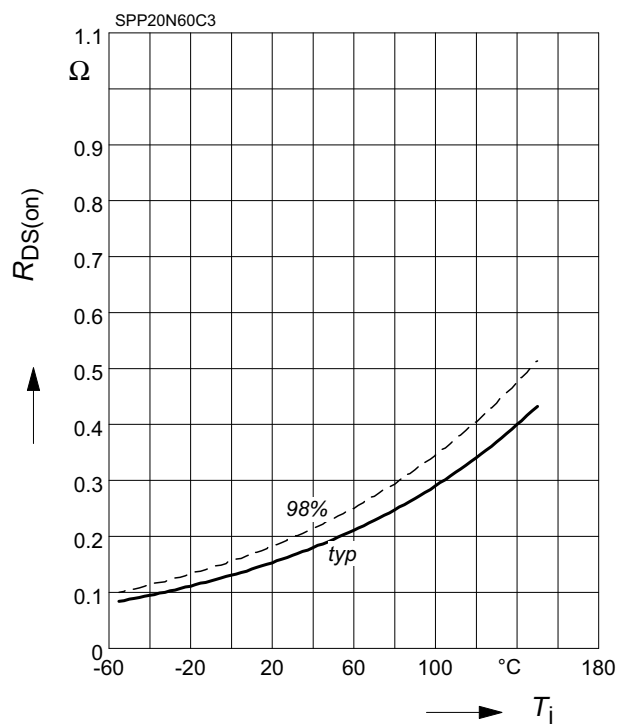
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



### 10 Drain-source on-state resistance

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

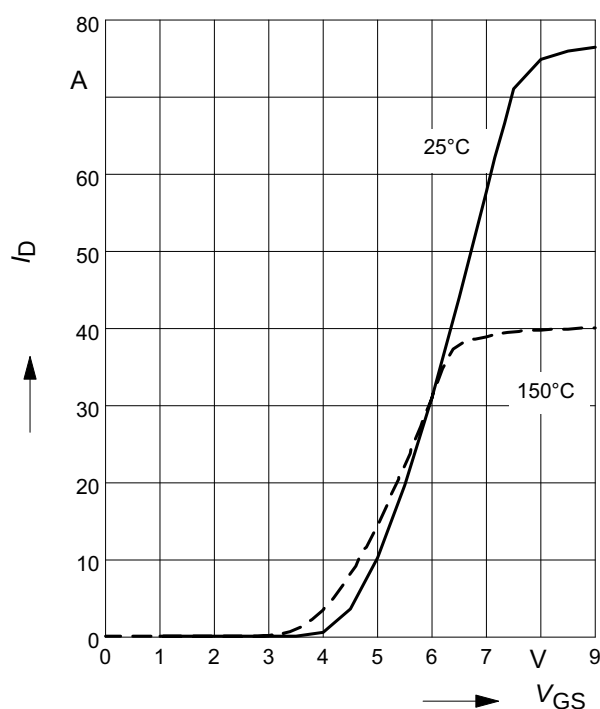
parameter:  $I_D = 13.1$  A,  $V_{GS} = 10$  V



### 11 Typ. transfer characteristics

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

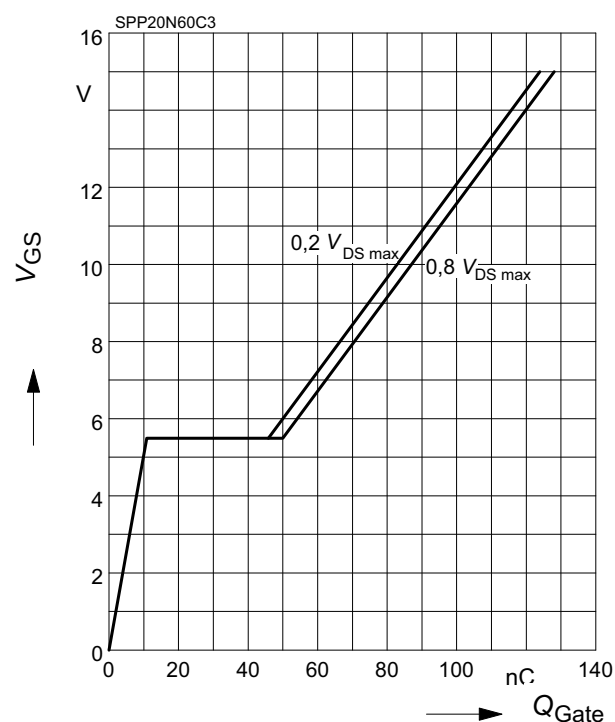
parameter:  $t_p = 10$   $\mu\text{s}$



### 12 Typ. gate charge

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

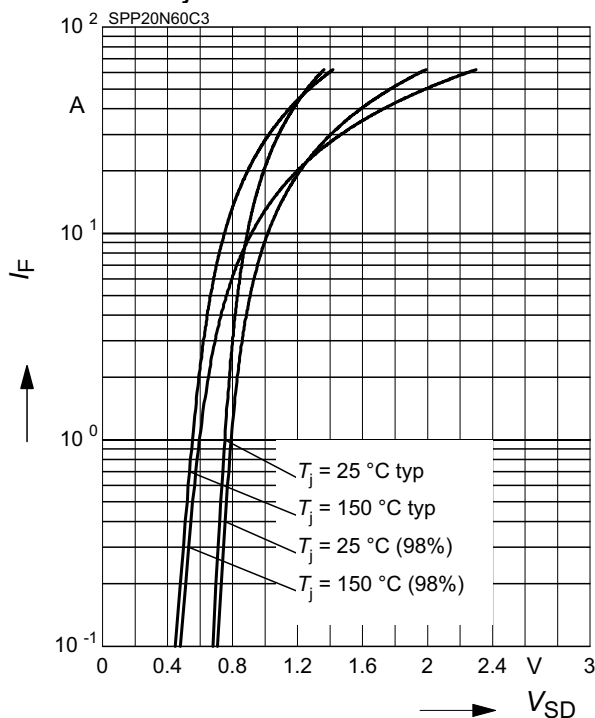
parameter:  $I_D = 20.7$  A pulsed



### 13 Forward characteristics of body diode

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

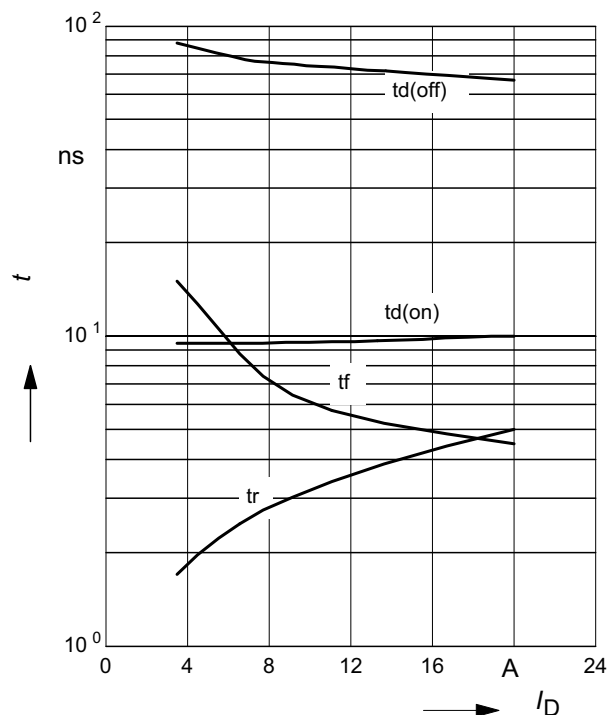
parameter:  $T_j$ ,  $t_p = 10 \mu s$



### 14 Typ. switching time

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

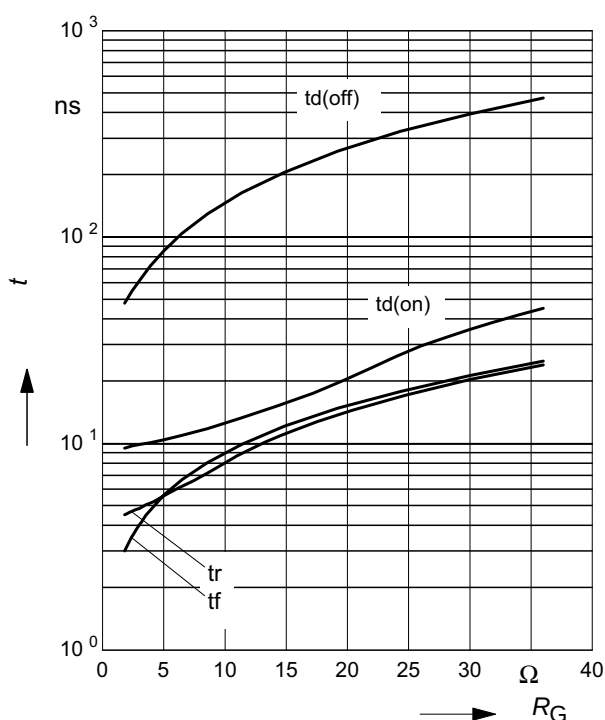
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $R_G = 3.6\Omega$



### 15 Typ. switching time

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

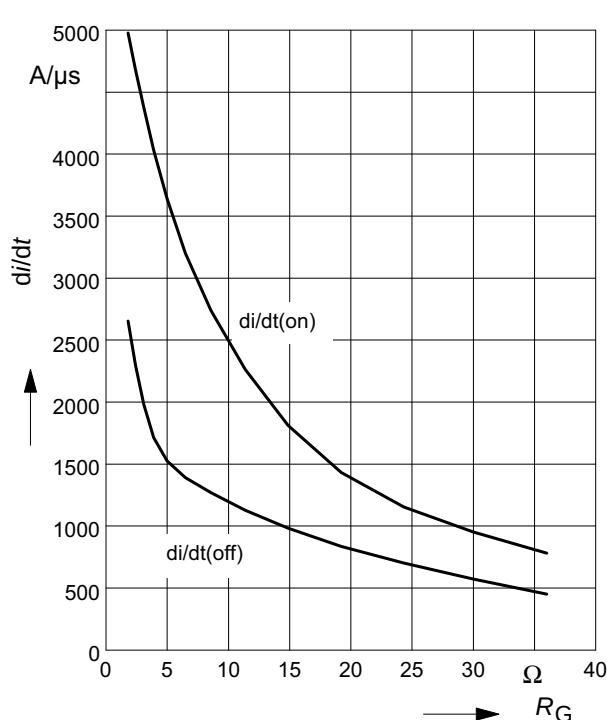
par.:  $V_{DS} = 380V$ ,  $V_{GS} = 0/+13V$ ,  $I_D = 20.7 A$



### 16 Typ. drain current slope

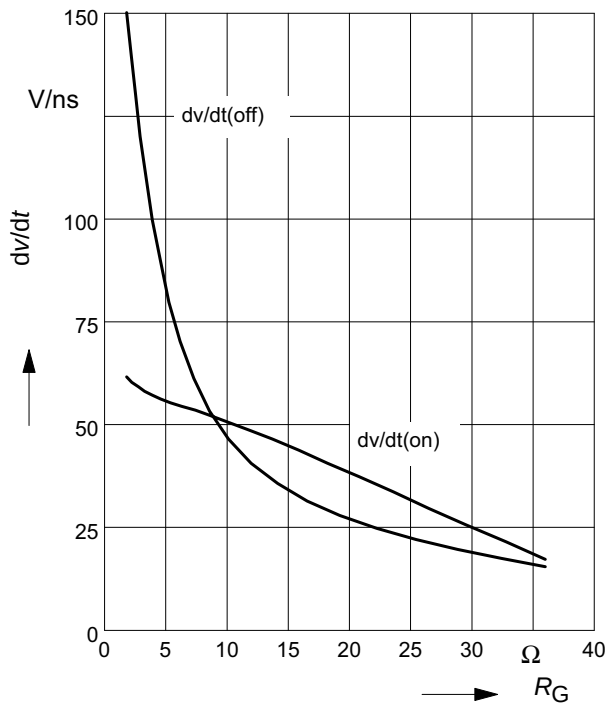
$$di/dt = f(R_G), \text{ inductive load, } T_j = 125^\circ C$$

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



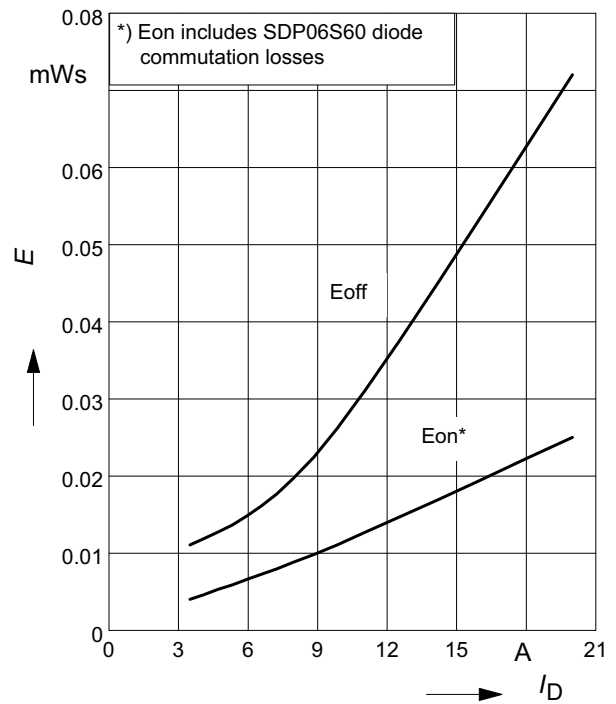
### 17 Typ. drain source voltage slope

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



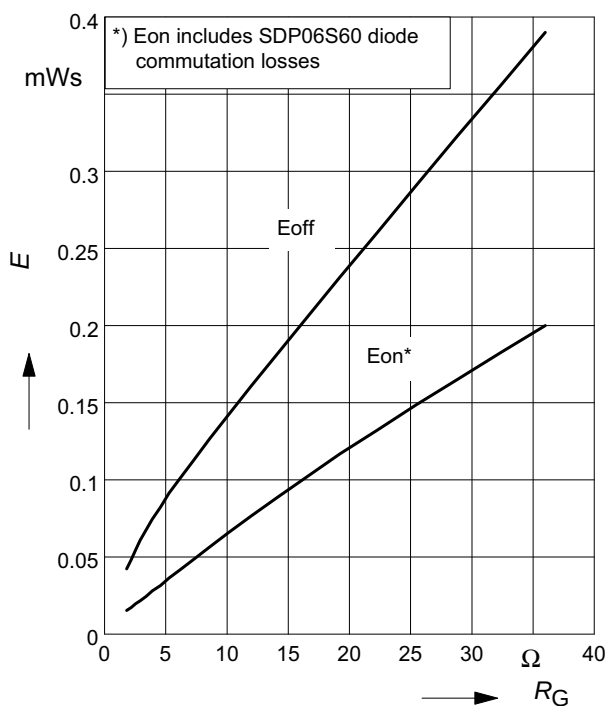
### 18 Typ. switching losses

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



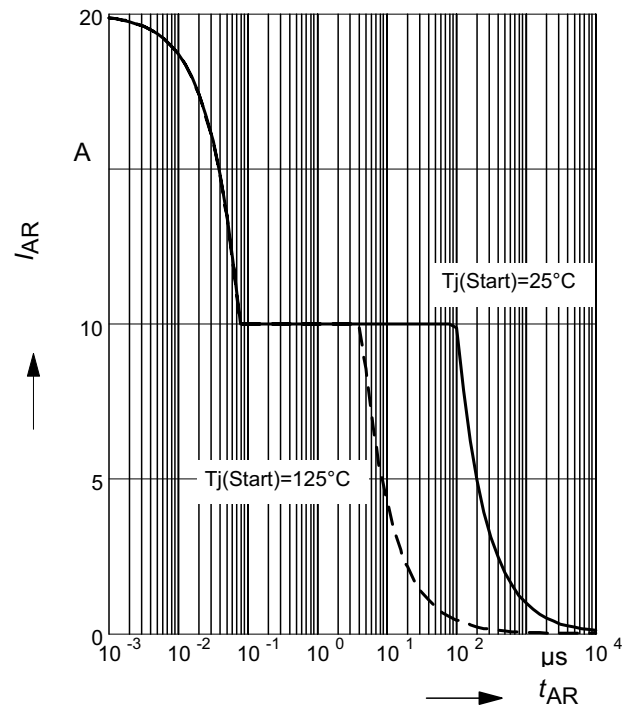
### 19 Typ. switching losses

$E = f(R_G)$ , 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

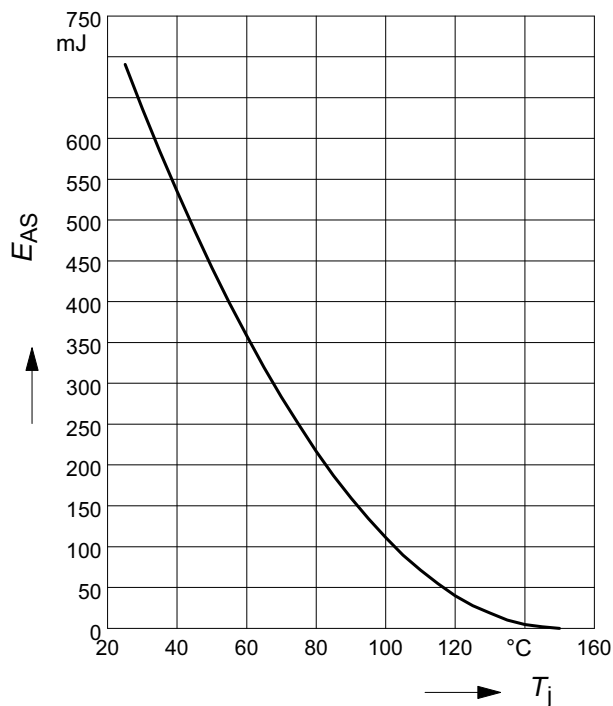
$I_{AR} = f(t_{AR})$   
par.:  $T_j \leq 150^\circ\text{C}$



## 21 Avalanche energy

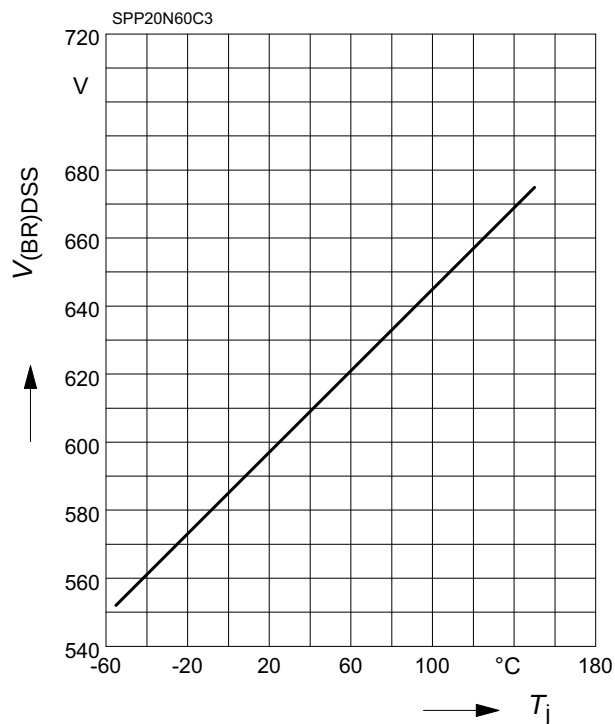
$$E_{AS} = f(T_j)$$

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



## 22 Drain-source breakdown voltage

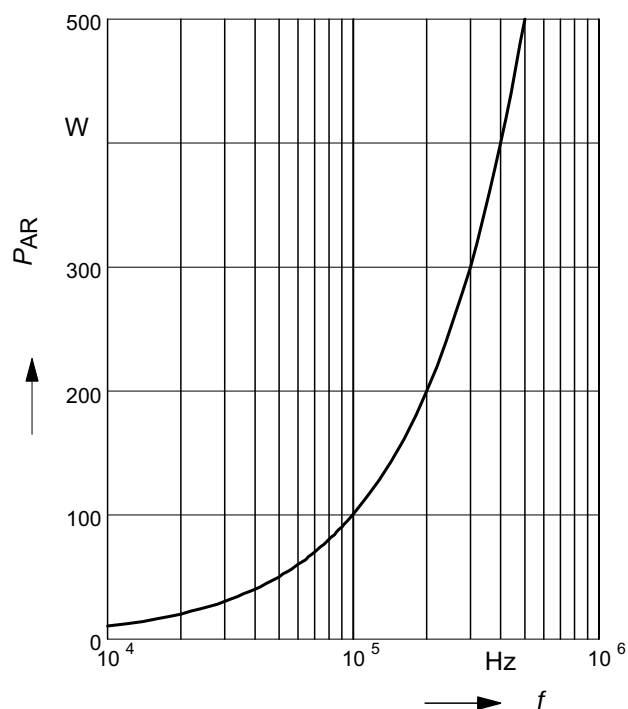
$$V_{(BR)DSS} = f(T_j)$$



## 23 Avalanche power losses

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

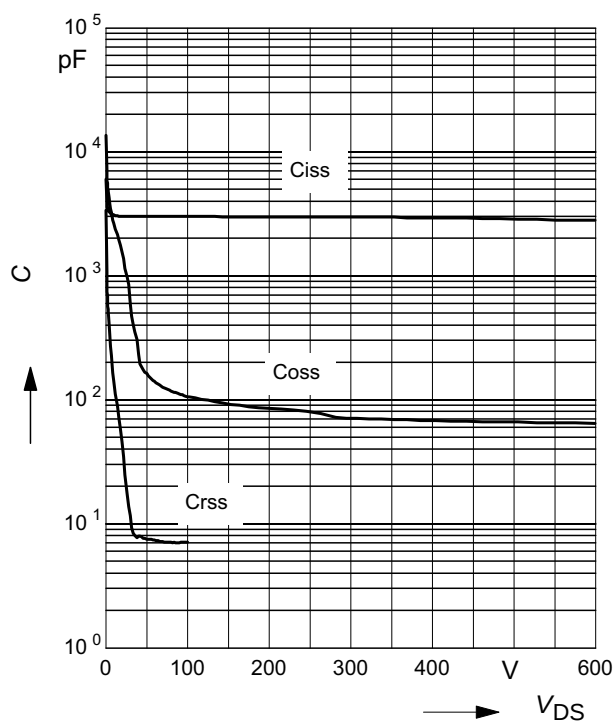
parameter:  $E_{AR} = 1\text{ mJ}$



## 24 Typ. capacitances

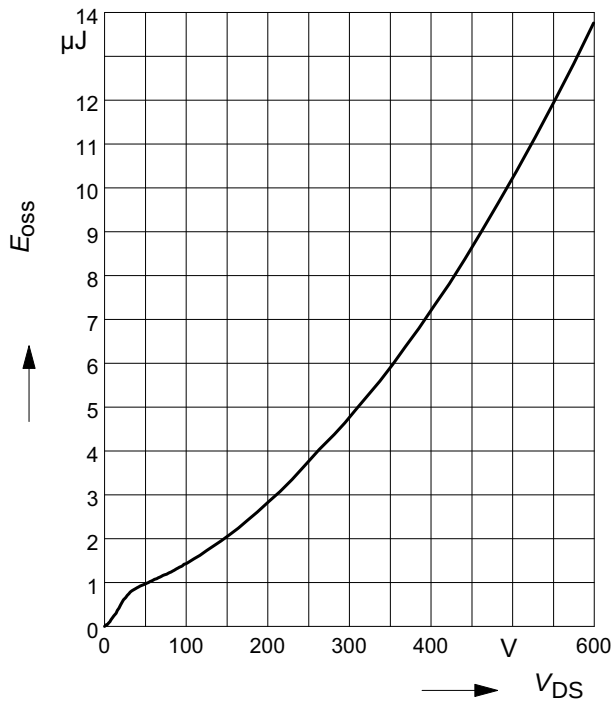
$$C = f(V_{DS})$$

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

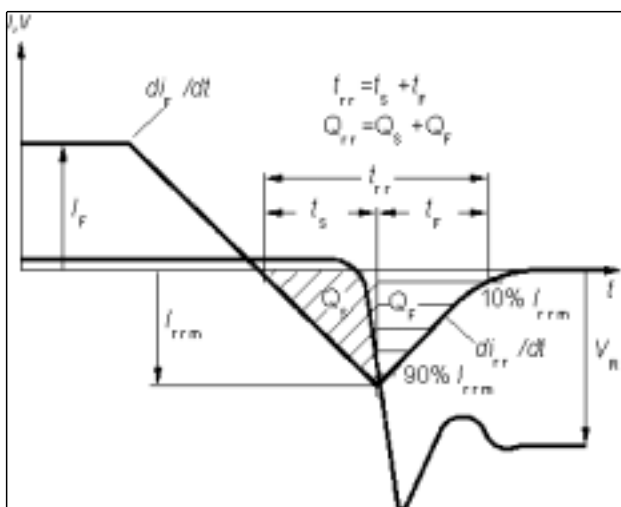


## 25 Typ. $C_{oss}$ stored energy

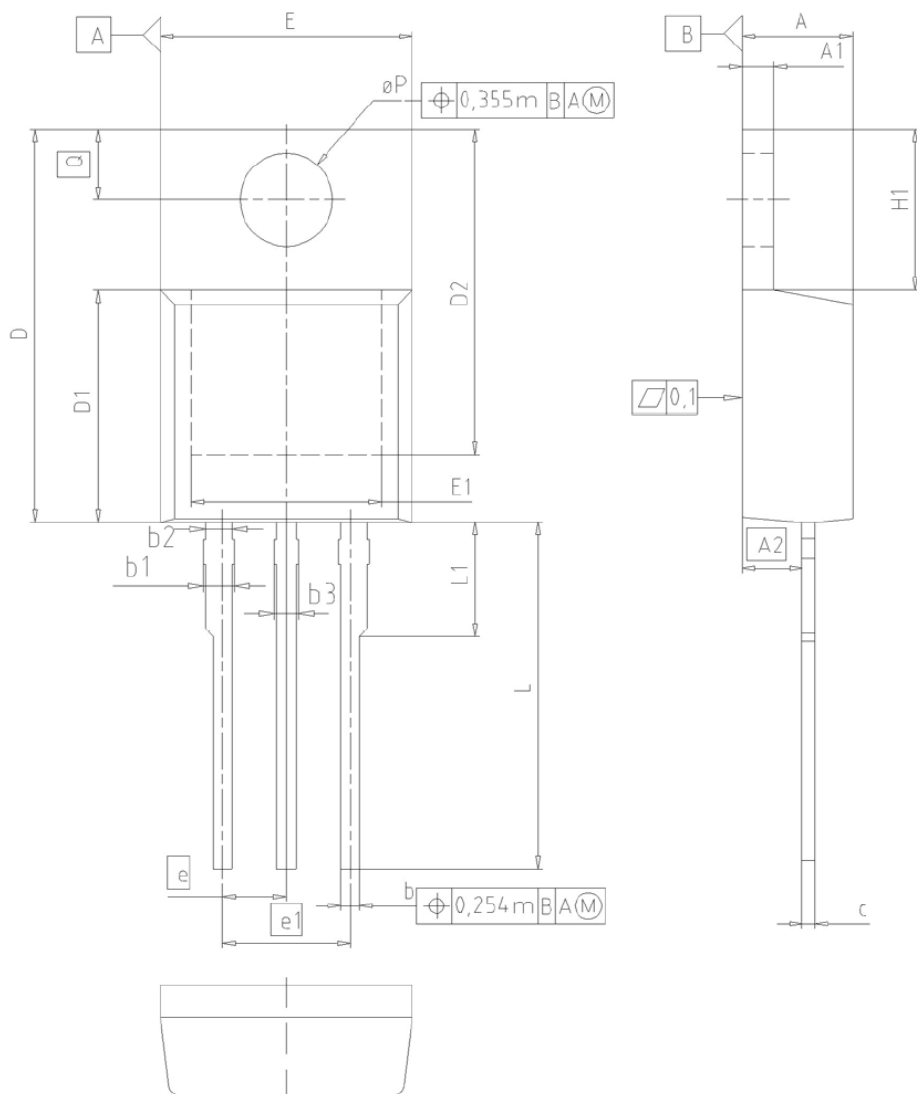
$$E_{oss} = f(V_{DS})$$



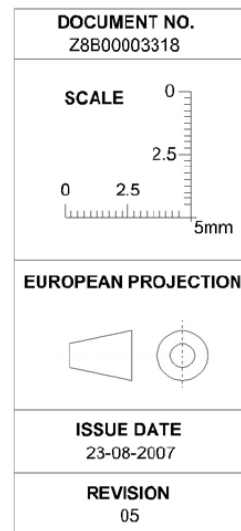
## Definition of diodes switching characteristics



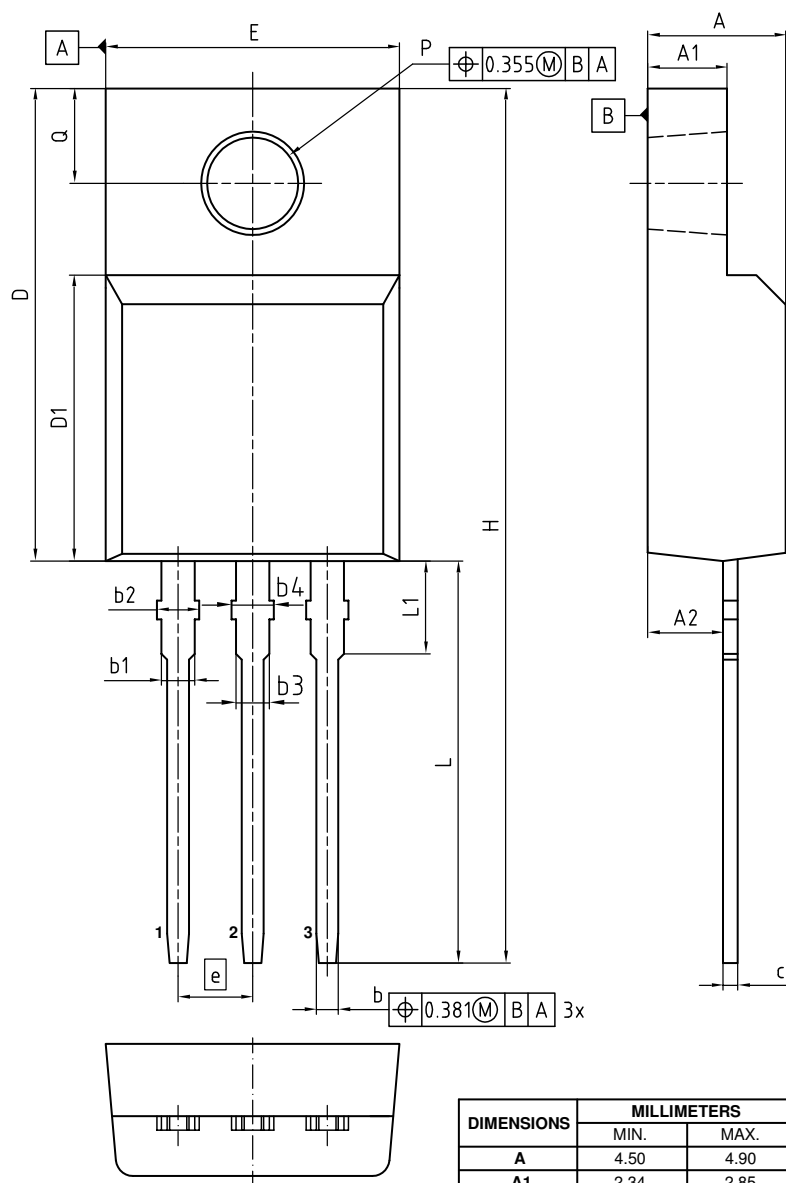
PG-TO220-3-1, PG-TO220-3-21 : Outline



| 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 |
| øP  | 3.60        | 3.89  | 0.142  | 0.153 |
| Q   | 2.60        | 3.00  | 0.102  | 0.118 |

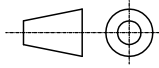


Outline PG-TO220 FullPAK

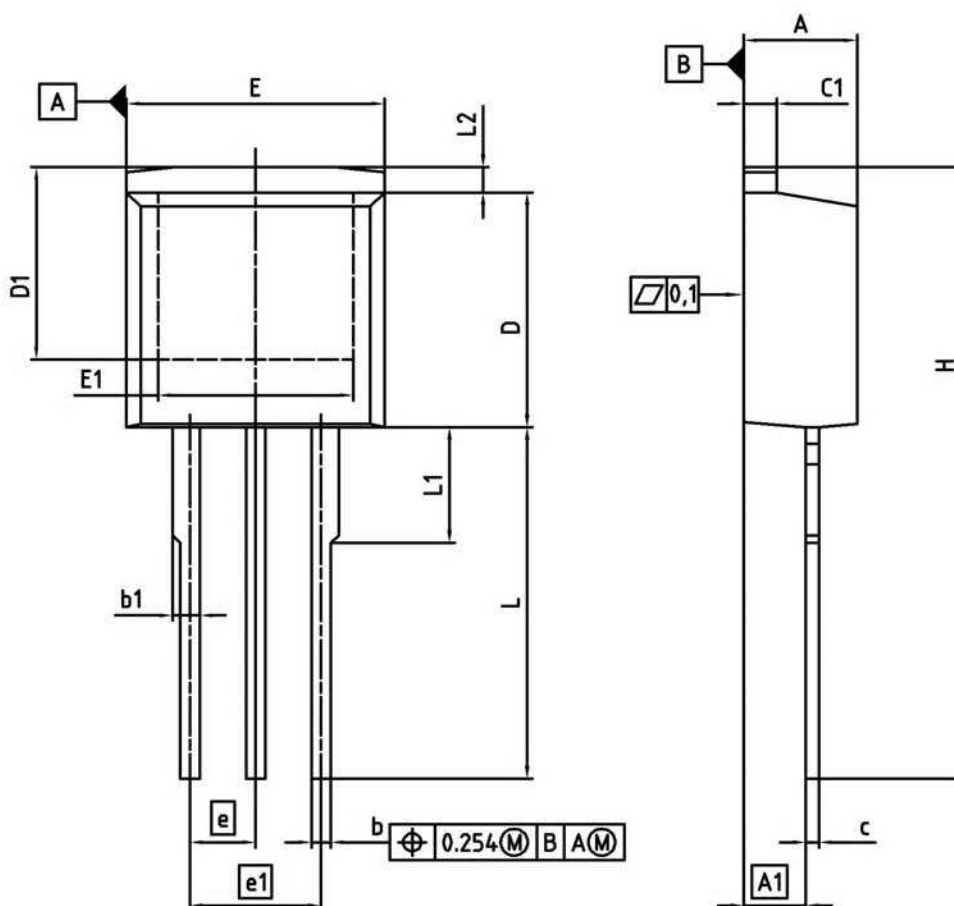


NOTES:  
 ALL DIMENSIONS REFER TO JEDEC STANDARD TO-281  
 AND DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS  
 OR GATE BURRS  
 GATE BURRS ARE LESS THAN 0.5 mm

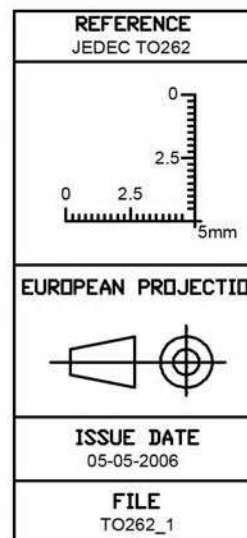
| DIMENSIONS | MILLIMETERS |       |
|------------|-------------|-------|
|            | MIN.        | MAX.  |
| A          | 4.50        | 4.90  |
| A1         | 2.34        | 2.85  |
| A2         | 2.42        | 2.86  |
| b          | 0.65        | 0.90  |
| b1         | 0.95        | 1.38  |
| b2         | 0.95        | 1.51  |
| b3         | 0.65        | 1.38  |
| b4         | 0.65        | 1.51  |
| c          | 0.40        | 0.63  |
| D          | 15.67       | 16.15 |
| D1         | 8.97        | 9.83  |
| E          | 10.00       | 10.65 |
| e          | 2.54        |       |
| H          | 28.70       | 29.75 |
| L          | 12.78       | 13.75 |
| L1         | 2.83        | 3.45  |
| øP         | 3.00        | 3.30  |
| Q          | 3.15        | 3.50  |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NO.</b><br>Z8B00003319                                                                                  |
| <b>REVISION</b><br>07                                                                                               |
| <b>SCALE 5:1</b><br>0 1 2 3 4 5mm                                                                                   |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>27.01.2017                                                                                     |

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 |



## Revision History

SPx20N60C3

**Revision: 2018-02-27, Rev. 2.2**

Previous Revision

| Revision | Date       | Subjects (major changes since last revision) |
|----------|------------|----------------------------------------------|
| 3.2      | 2018-02-27 | Outline PG-TO-220 FullPAK update             |

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