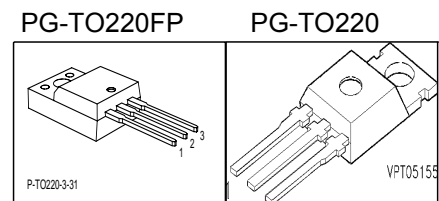


## Cool MOS™ Power Transistor

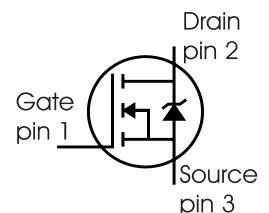
### Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Improved transconductance
- PG-TO-220-3-31;-3-111: 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        |
| $R_{DS(on)}$        | 1.4 | $\Omega$ |
| $I_D$               | 3.2 | A        |



| Type       | Package    | Ordering Code | Marking |
|------------|------------|---------------|---------|
| SPP03N60C3 | PG-TO220   | Q67040-S4401  | 03N60C3 |
| SPA03N60C3 | PG-TO220FP | SP000216296   | 03N60C3 |



### Maximum Ratings

| Parameter                                                                                                            | Symbol              | Value      |                                      | Unit             |
|----------------------------------------------------------------------------------------------------------------------|---------------------|------------|--------------------------------------|------------------|
|                                                                                                                      |                     | SPP        | SPA                                  |                  |
| 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   | 3.2 <sup>1)</sup><br>2 <sup>1)</sup> | A                |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$                                                                    | $I_{D\text{ puls}}$ | 9.6        | 9.6                                  | A                |
| Avalanche energy, single pulse<br>$I_D=2.4\text{A}$ , $V_{DD}=50\text{V}$                                            | $E_{AS}$            | 100        | 100                                  | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup><br>$I_D=3.2\text{A}$ , $V_{DD}=50\text{V}$ | $E_{AR}$            | 0.2        | 0.2                                  |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$                                                         | $I_{AR}$            | 3.2        | 3.2                                  | 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, $T_C = 25\text{ }^\circ\text{C}$                                                                  | $P_{tot}$           | 38         | 29.7                                 | 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>$V_{DS} = 480\text{ V}$ , $I_D = 3.2\text{ A}$ , $T_j = 125\text{ °C}$ | $dv/dt$ | 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 - case, FullPAK                                                      | $R_{thJC\text{ FP}}$ | -      | -    | 4.1  |      |
| 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  $T_j=25\text{ °C}$  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>$T_j=25\text{ °C}$<br>$T_j=150\text{ °C}$ | -      | 0.5  | 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         | $R_{DS(on)}$  | $V_{GS}=10\text{V}$ , $I_D=2\text{A}$<br>$T_j=25\text{ °C}$<br>$T_j=150\text{ °C}$       | -      | 1.26 | 1.4  | $\Omega$      |
| Gate input resistance                    | $R_G$         | $f=1\text{MHz}$ , open drain                                                             | -      | 10   | -    |               |

**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>$I_D = 2A$ | -      | 3.4  | -    | S    |
| Input capacitance                                             | $C_{iss}$    | $V_{GS} = 0V$ , $V_{DS} = 25V$ ,                              | -      | 400  | -    | pF   |
| Output capacitance                                            | $C_{oss}$    | $f = 1MHz$                                                    | -      | 150  | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |                                                               | -      | 5    | -    |      |
| Effective output capacitance, <sup>5)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0V$ ,<br>$V_{DS} = 0V$ to 480V                      | -      | 12   | -    |      |
| Effective output capacitance, <sup>6)</sup><br>time related   | $C_{o(tr)}$  |                                                               | -      | 26   | -    |      |
| Turn-on delay time                                            | $t_{d(on)}$  | $V_{DD} = 350V$ , $V_{GS} = 0/10V$ ,                          | -      | 7    | -    | ns   |
| Rise time                                                     | $t_r$        | $I_D = 3.2A$ ,                                                | -      | 3    | -    |      |
| Turn-off delay time                                           | $t_{d(off)}$ | $R_G = 20\Omega$                                              | -      | 64   | 100  |      |
| Fall time                                                     | $t_f$        |                                                               | -      | 12   | 20   |      |

**Gate Charge Characteristics**

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

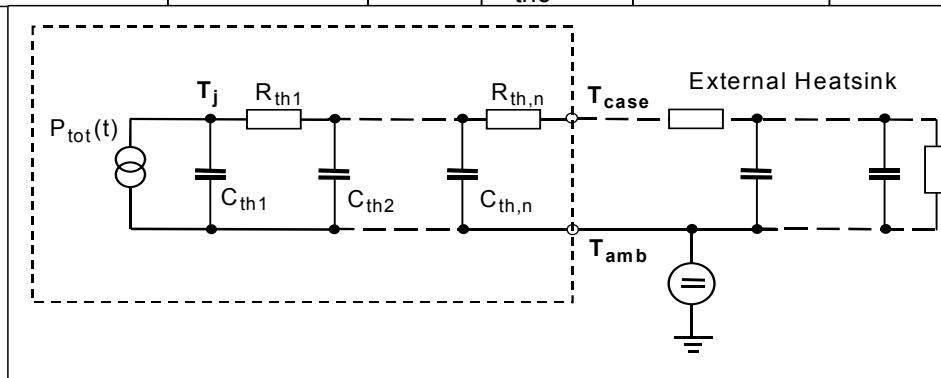
Identical low-side and high-side switch.

**Electrical Characteristics**

| Parameter                                     | Symbol       | Conditions                        | Values |      |      | Unit                   |
|-----------------------------------------------|--------------|-----------------------------------|--------|------|------|------------------------|
|                                               |              |                                   | min.   | typ. | max. |                        |
| Inverse diode continuous forward current      | $I_S$        | $T_C=25^\circ\text{C}$            | -      | -    | 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                         | $t_{rr}$     | $V_R=420\text{V}, I_F=I_S,$       | -      | 250  | 400  | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     | $di_F/dt=100\text{A}/\mu\text{s}$ | -      | 1.8  | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                   | -      | 15   | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ | $T_j=25^\circ\text{C}$            | -      | -    | -    | $\text{A}/\mu\text{s}$ |

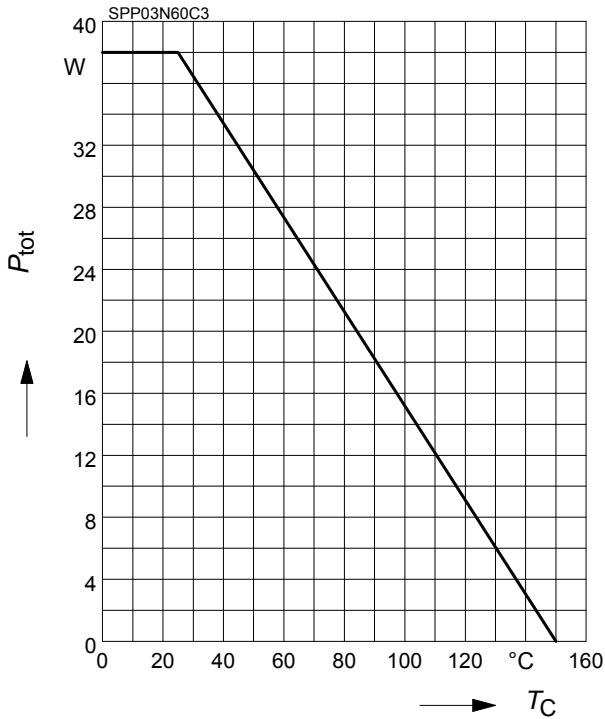
**Typical Transient Thermal Characteristics**

| Symbol    | Value |       | Unit | Symbol    | Value      |            | Unit |
|-----------|-------|-------|------|-----------|------------|------------|------|
|           | SPP   | SPA   |      |           | SPP        | SPA        |      |
| $R_{th1}$ | 0.054 | 0.054 | K/W  | $C_{th1}$ | 0.00005232 | 0.00005232 | Ws/K |
| $R_{th2}$ | 0.103 | 0.103 |      | $C_{th2}$ | 0.0002034  | 0.0002034  |      |
| $R_{th3}$ | 0.178 | 0.178 |      | $C_{th3}$ | 0.0002963  | 0.0002963  |      |
| $R_{th4}$ | 0.757 | 0.356 |      | $C_{th4}$ | 0.0009103  | 0.0009103  |      |
| $R_{th5}$ | 0.682 | 0.655 |      | $C_{th5}$ | 0.002084   | 0.004434   |      |
| $R_{th6}$ | 0.202 | 2.535 |      | $C_{th6}$ | 0.024      | 0.412      |      |



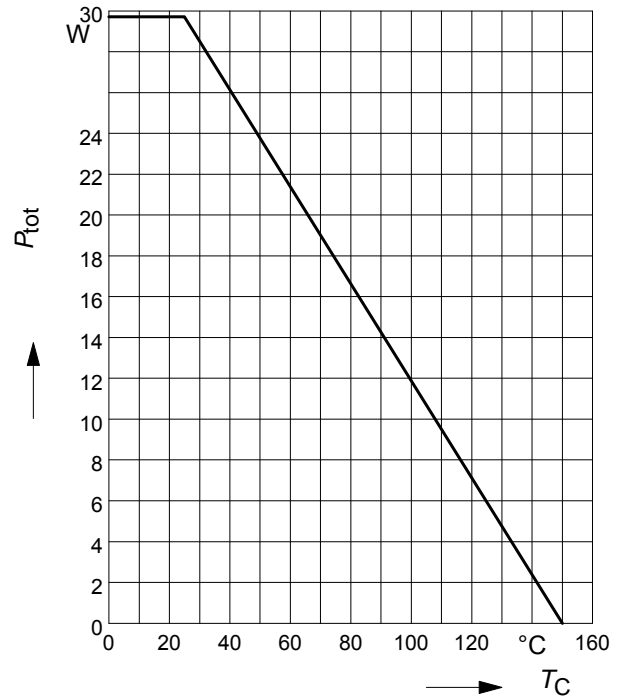
### 1 Power dissipation

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



### 2 Power dissipation FullPAK

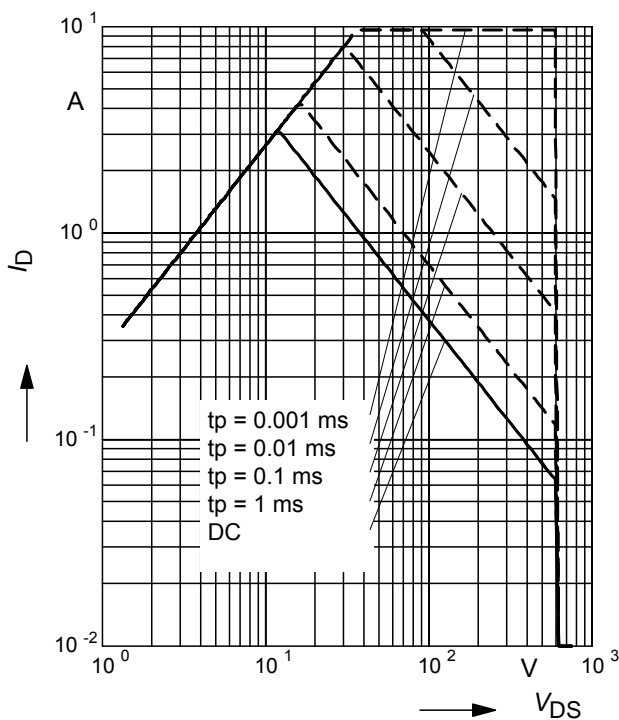
$$P_{tot} = f(T_C)$$



### 3 Safe operating area

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

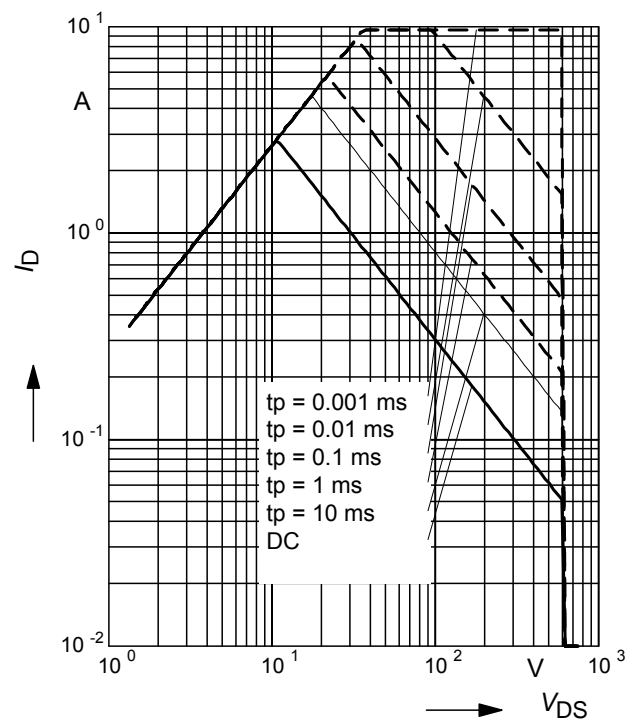
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 4 Safe operating area FullPAK

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

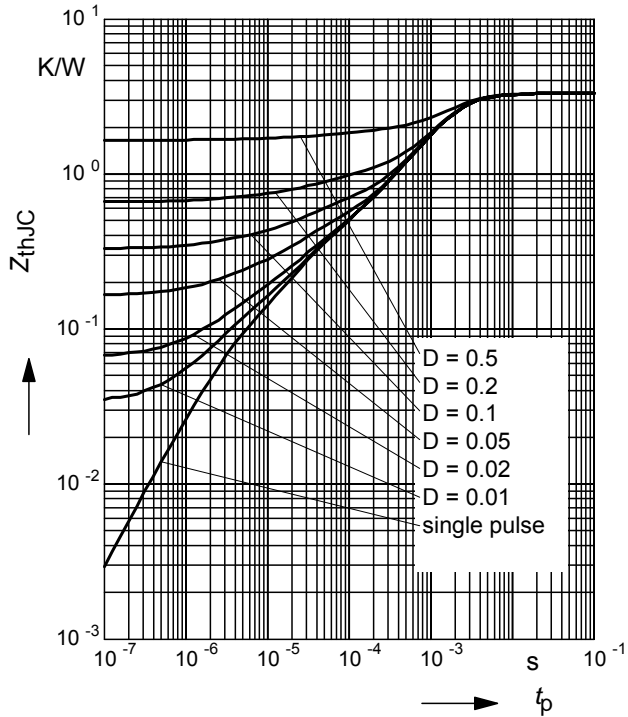
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 5 Transient thermal impedance

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

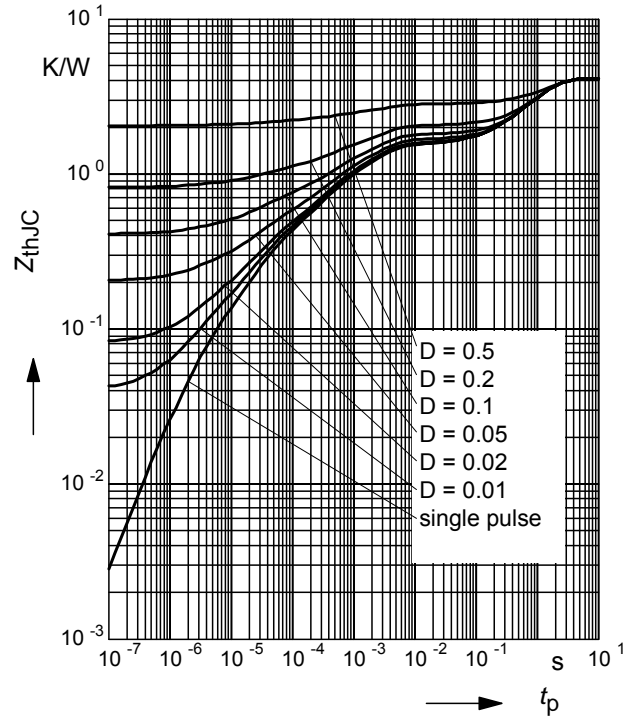
parameter:  $D = t_p/T$



### 6 Transient thermal impedance FullPAK

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

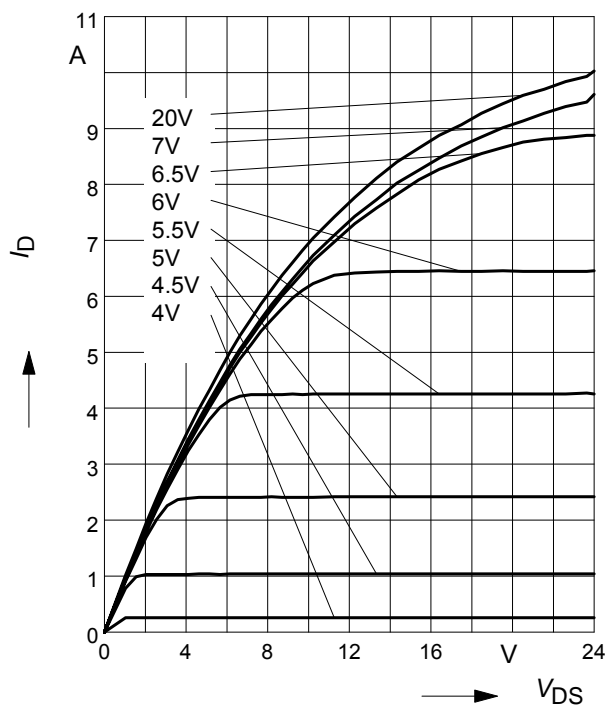
parameter:  $D = t_p/t$



### 7 Typ. output characteristic

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

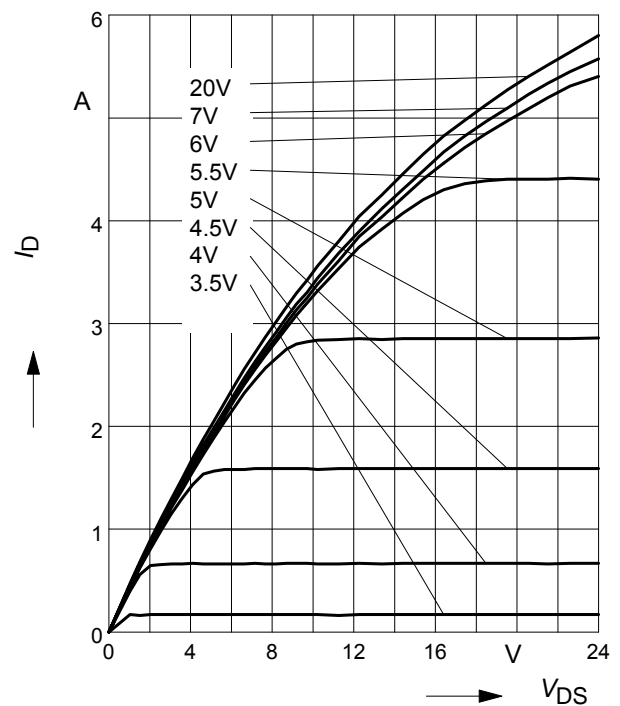
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



### 8 Typ. output characteristic

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

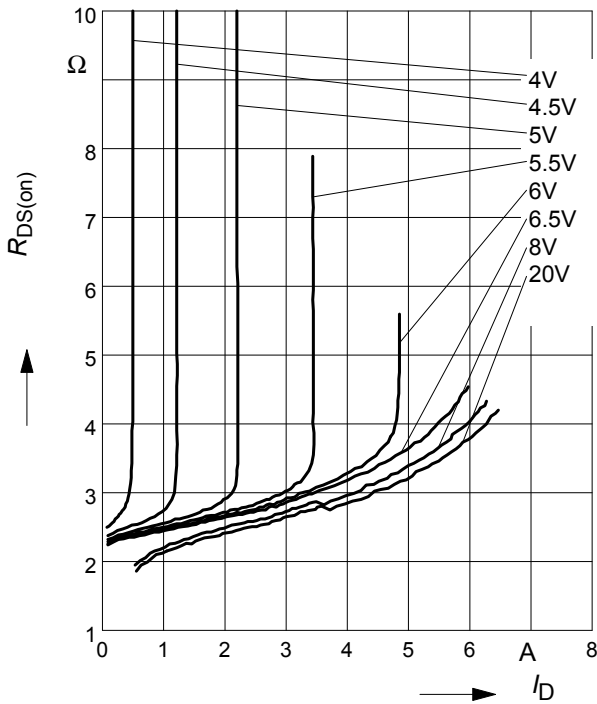
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

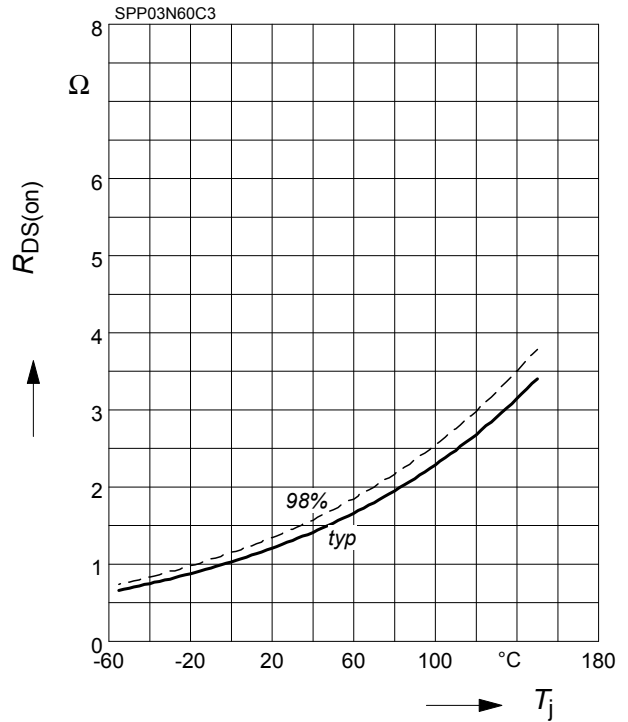
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



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

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

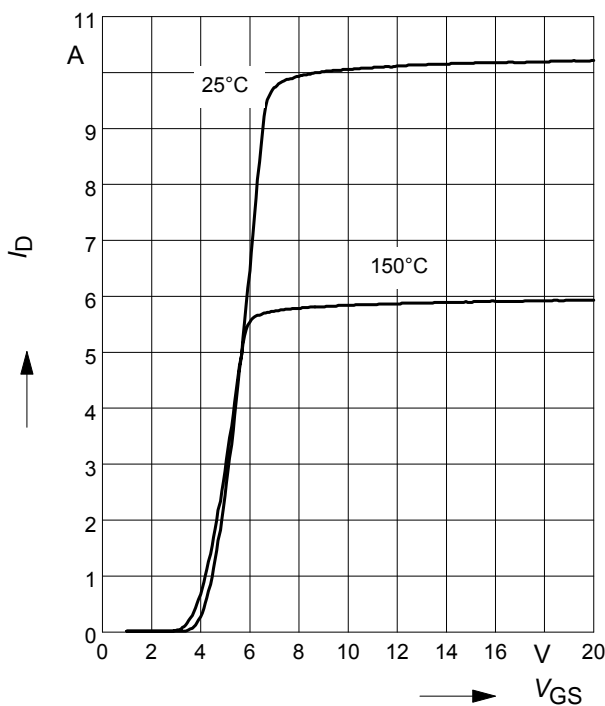
parameter:  $I_D = 2\text{ A}$ ,  $V_{GS} = 10\text{ V}$



**11 Typ. transfer characteristics**

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

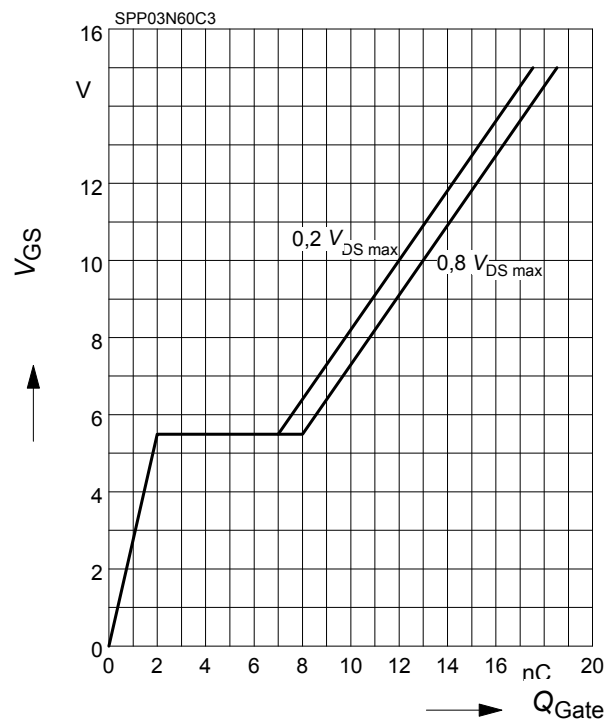
parameter:  $t_p = 10\ \mu\text{s}$



**12 Typ. gate charge**

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

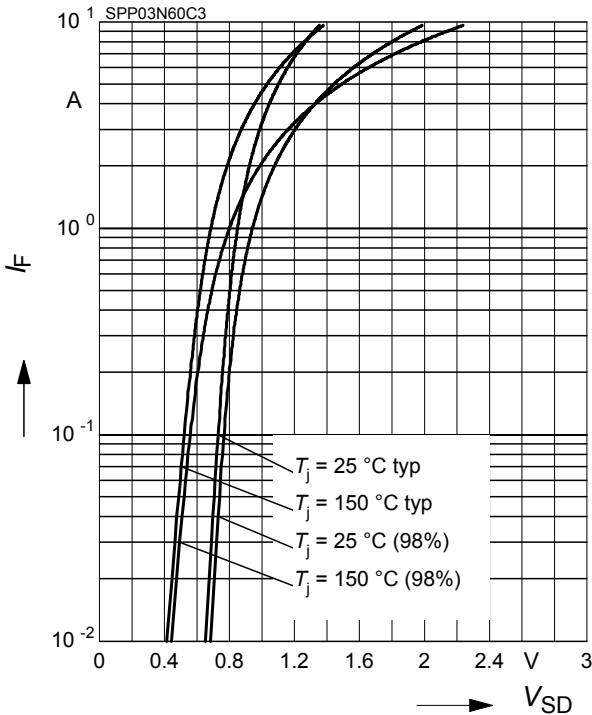
parameter:  $I_D = 3.2\text{ A pulsed}$



**13 Forward characteristics of body diode**

$I_F = f(V_{SD})$

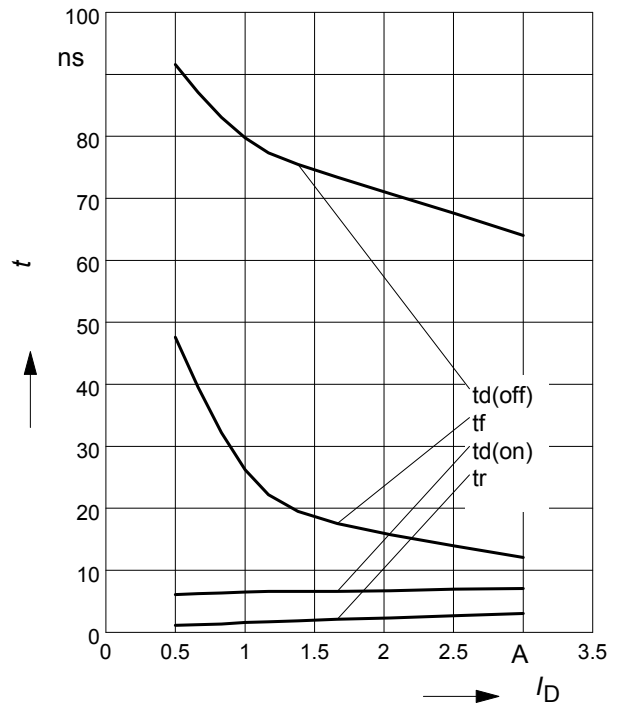
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Typ. switching time**

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

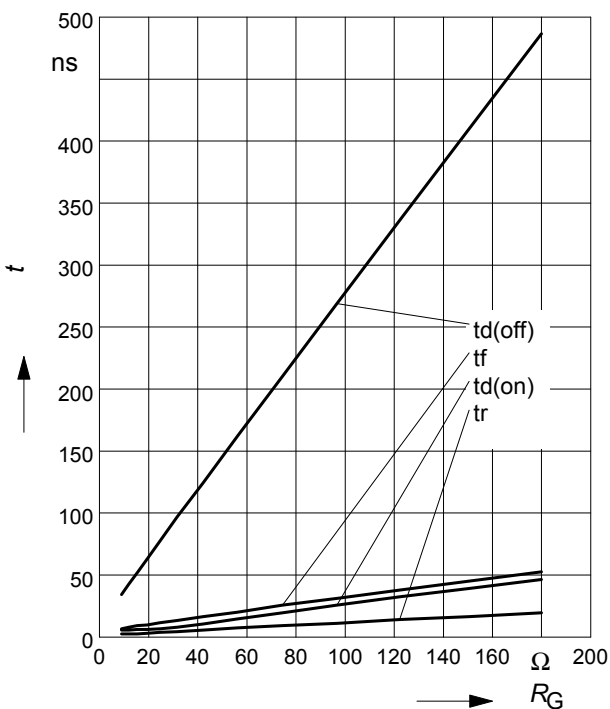
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $R_G=20\Omega$



**15 Typ. switching time**

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

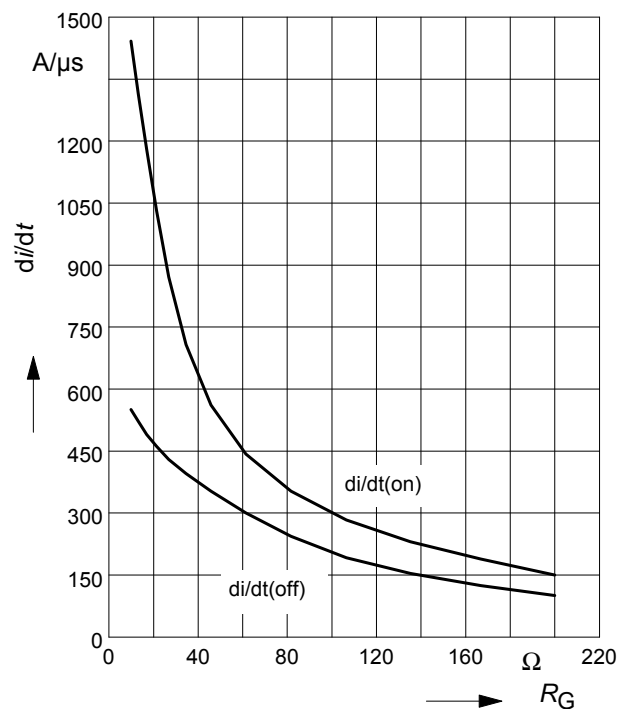
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $I_D=3.2 A$



**16 Typ. drain current slope**

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

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

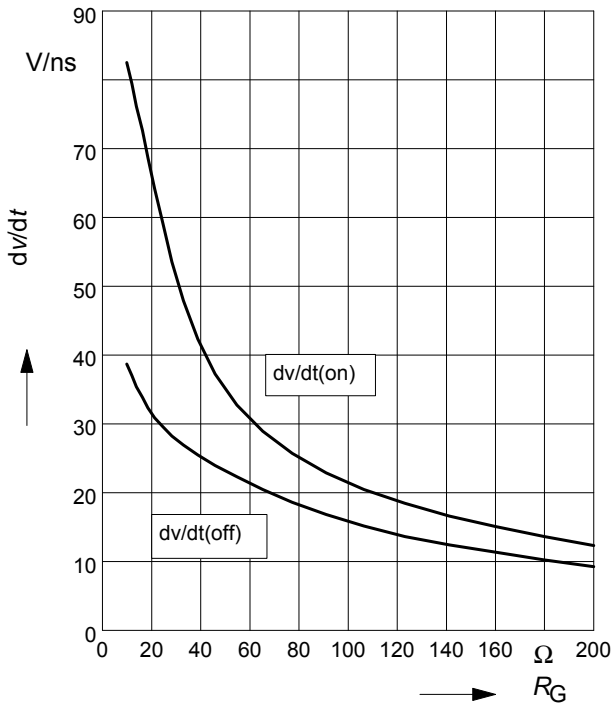




**17 Typ. drain source voltage slope**

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

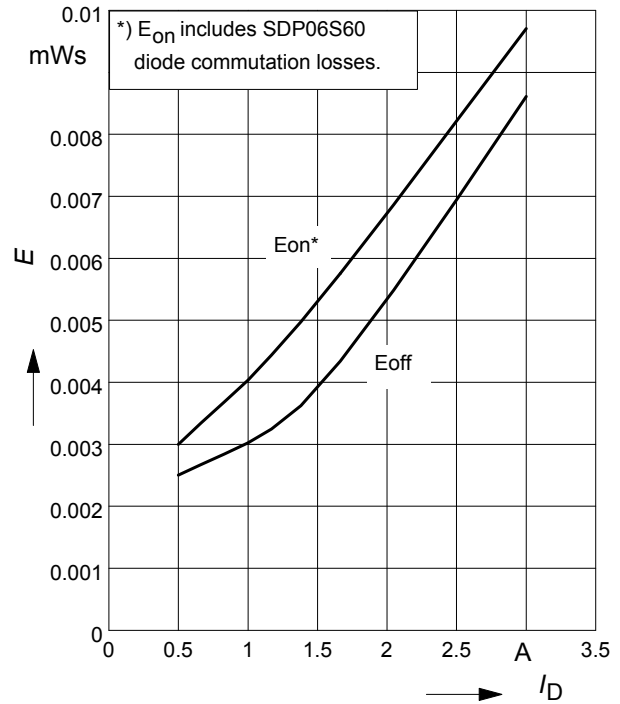
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=3.2\text{A}$



**18 Typ. switching losses**

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

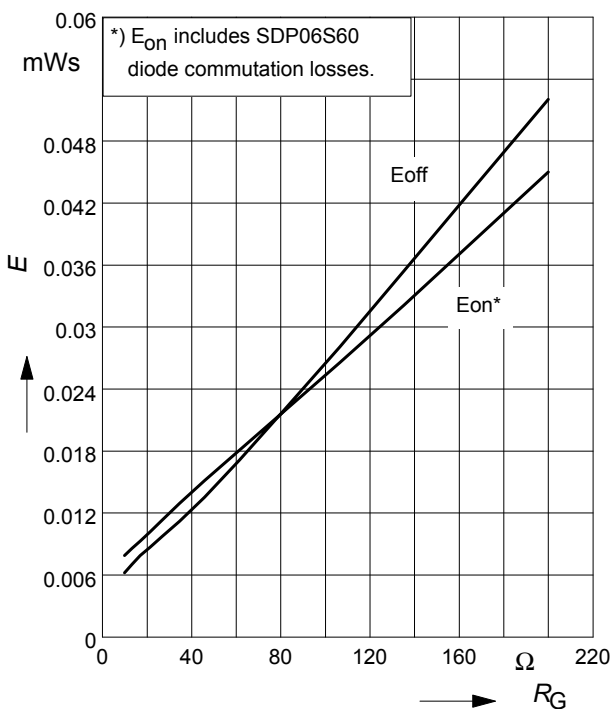
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=20\Omega$



**19 Typ. switching losses**

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

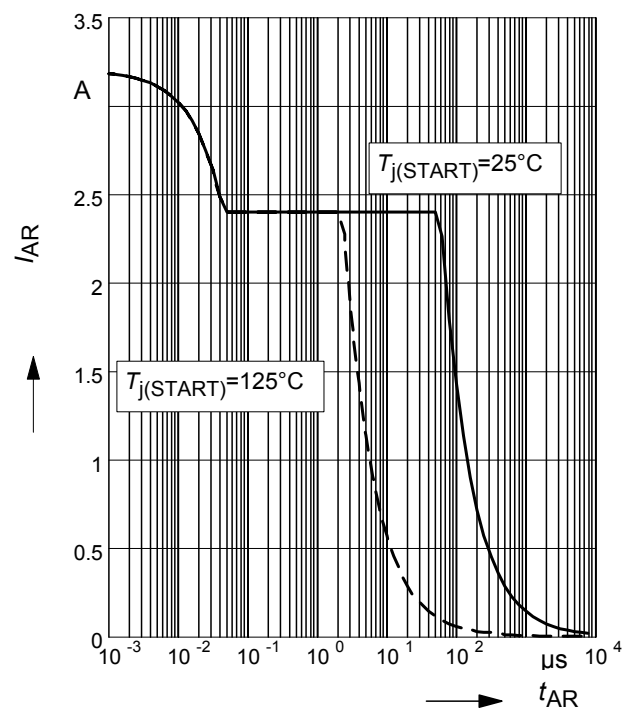
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=3.2\text{A}$



**20 Avalanche SOA**

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

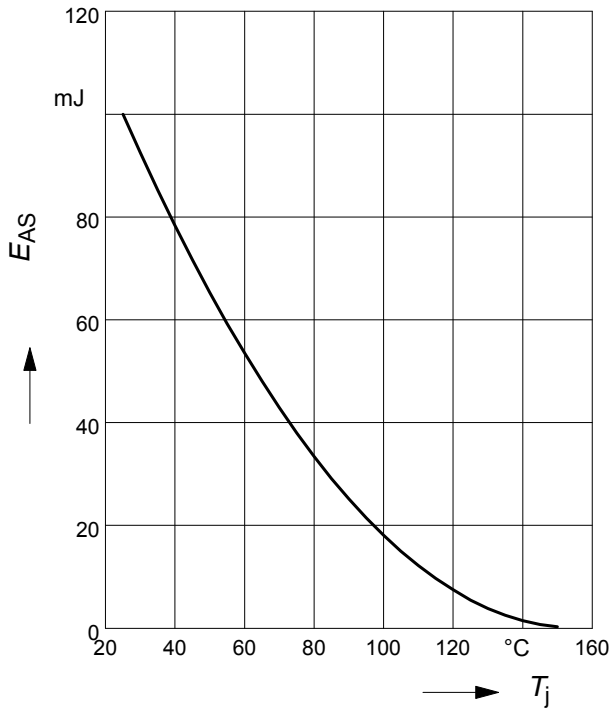
par.:  $T_j \leq 150^\circ\text{C}$



### 21 Avalanche energy

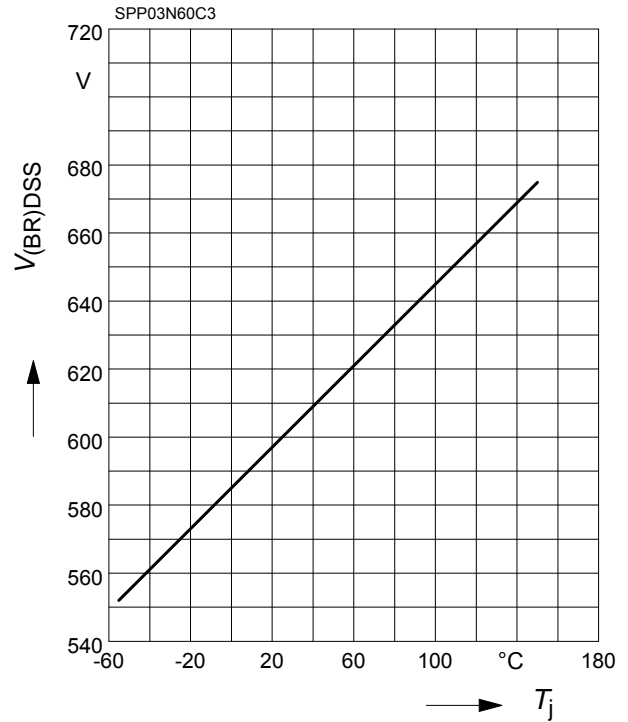
$$E_{AS} = f(T_j)$$

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



### 22 Drain-source breakdown voltage

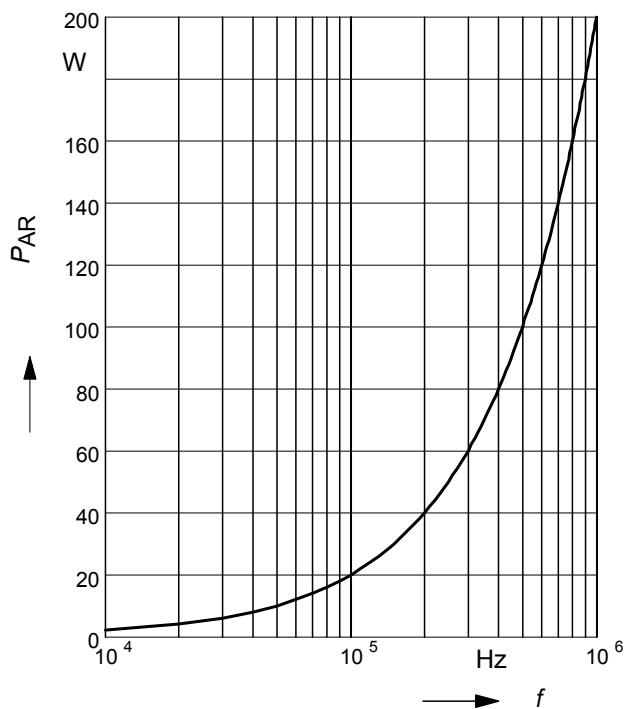
$$V_{(BR)DSS} = f(T_j)$$



### 23 Avalanche power losses

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

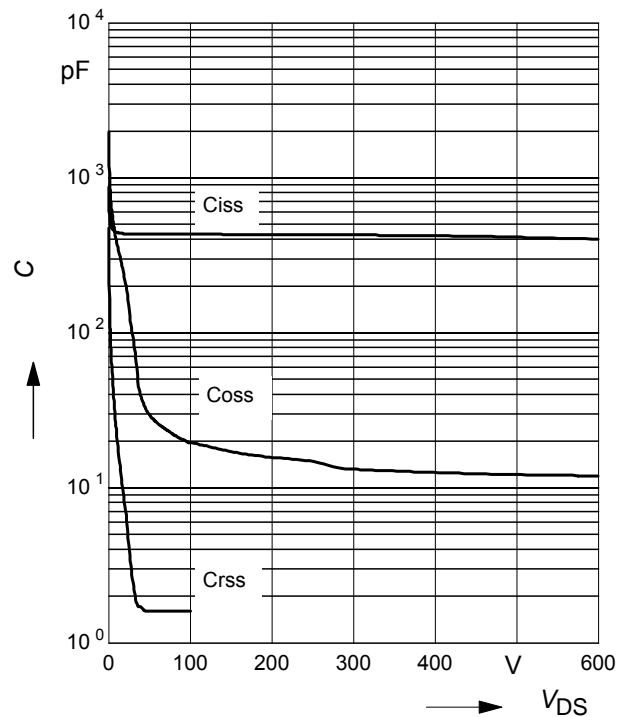
parameter:  $E_{AR} = 0.2 \text{ mJ}$



### 24 Typ. capacitances

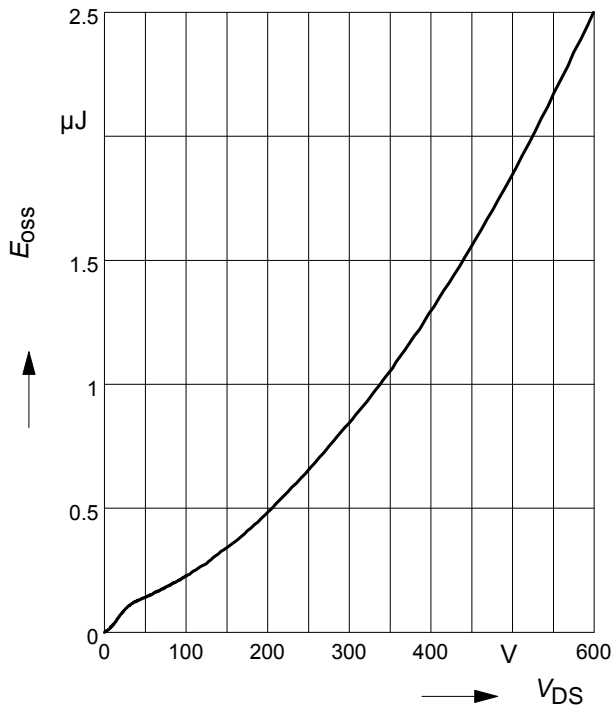
$$C = f(V_{DS})$$

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

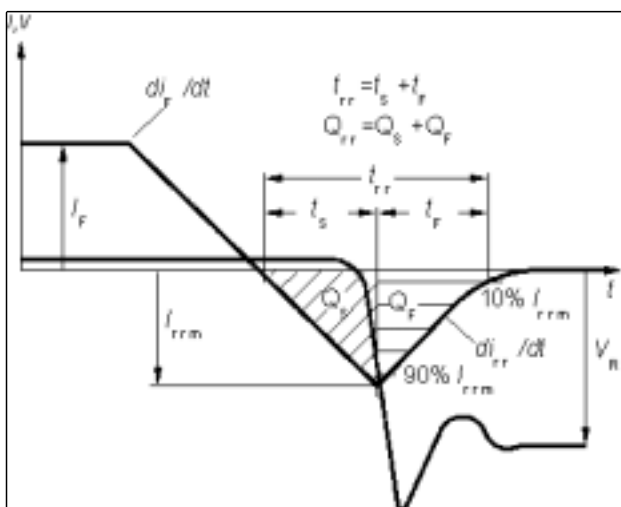


25 Typ.  $C_{oss}$  stored energy

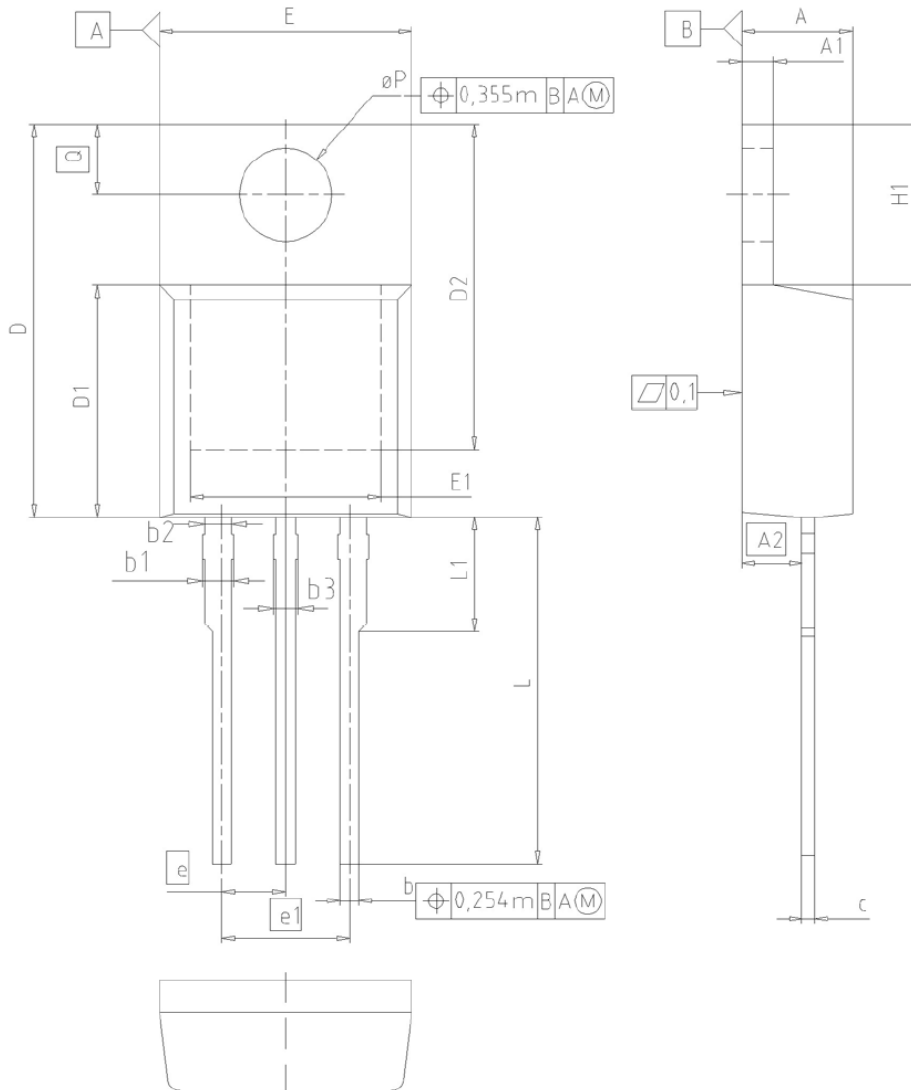
$$E_{oss} = f(V_{DS})$$



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.  
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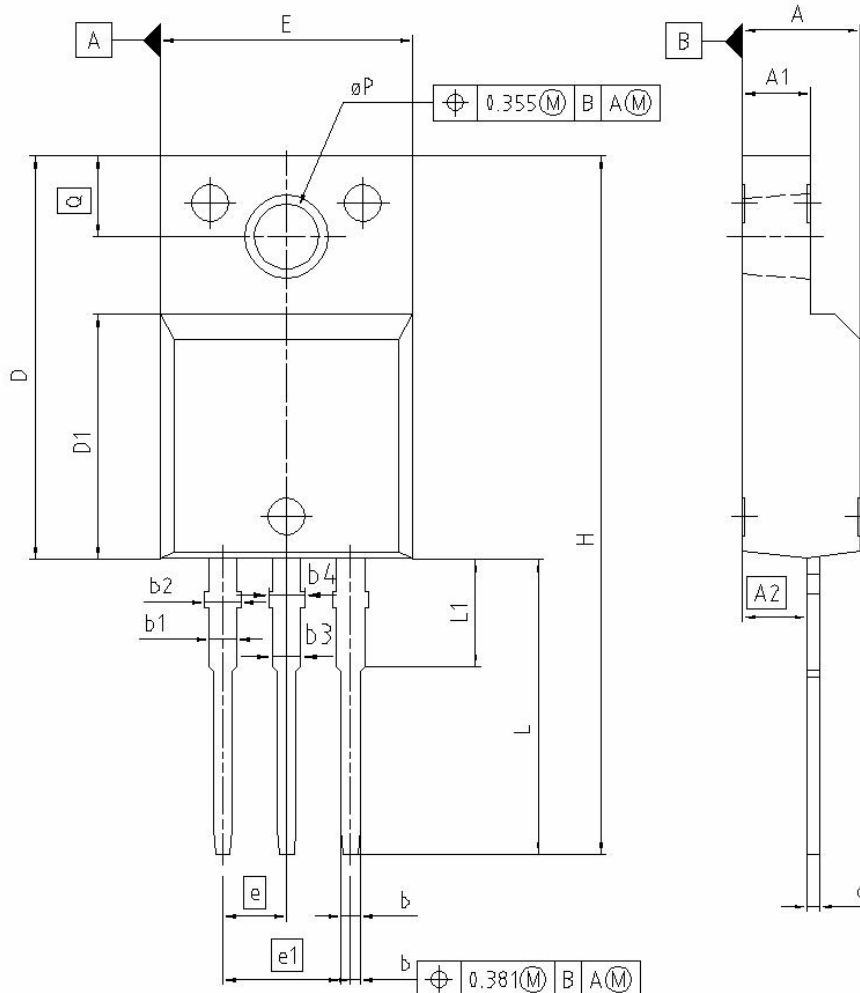
SCALE

EUROPEAN PROJECTION

ISSUE DATE  
23-08-2007

REVISION  
05

PG-TO220-3-31/3-111 Fully isolated package (2500VAC; 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 |
| øP  | 2.95        | 3.20  | 0.116  | 0.126 |
| Q   | 3.15        | 3.50  | 0.124  | 0.138 |

**REFERENCE**  
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**SCALE**  
0 2.5 5mm

**EUROPEAN PROJECTION**

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**FILE**  
TO220\_2

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