

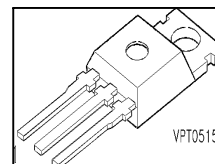
## Cool MOS™ Power Transistor

### Feature

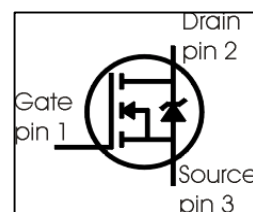
- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- High peak current capability
- Intrinsic fast-recovery body diode
- Extreme low reverse recovery charge
- Pb-free lead plating; RoHS compliant; Halogen free mold compound
- Qualified for industrial grade applications according to JEDEC<sup>0)</sup>

|                     |      |          |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 650  | V        |
| $R_{DS(on)}$        | 0.22 | $\Omega$ |
| $I_D$               | 20.7 | A        |

PG-TO220



| Type        | Package  | Ordering Code | Marking  |
|-------------|----------|---------------|----------|
| SPP20N60CFD | PG-TO220 | Q67040-S4616  | 20N60CFD |



### Maximum Ratings

| Parameter                                                                                                                 | Symbol              | Value        | Unit             |
|---------------------------------------------------------------------------------------------------------------------------|---------------------|--------------|------------------|
| Continuous drain current<br>$T_C = 25\text{ }^\circ\text{C}$<br>$T_C = 100\text{ }^\circ\text{C}$                         | $I_D$               | 20.7<br>13.1 | A                |
| Pulsed drain current, $t_D$ limited by $T_{jmax}$                                                                         | $I_{D\text{ puls}}$ | 52           |                  |
| Avalanche energy, single pulse<br>$I_D = 10\text{ A}$ , $V_{DD} = 50\text{ V}$                                            | $E_{AS}$            | 690          | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1)</sup><br>$I_D = 20\text{ A}$ , $V_{DD} = 50\text{ V}$ | $E_{AR}$            | 1            |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$                                                              | $I_{AR}$            | 20           | A                |
| Reverse diode $dv/dt$<br>$I_S = 20.7\text{ A}$ , $V_{DS} = 480\text{ V}$ , $T_j = 125\text{ }^\circ\text{C}$              | $dv/dt$             | 40           | V/ns             |
| Gate source voltage                                                                                                       | $V_{GS}$            | $\pm 20$     | V                |
| Gate source voltage AC ( $f > 1\text{ Hz}$ )                                                                              | $V_{GS}$            | $\pm 30$     |                  |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$                                                                       | $P_{tot}$           | 208          | W                |
| Operating and storage temperature                                                                                         | $T_j, T_{sta}$      | -55... +150  | $^\circ\text{C}$ |

**Maximum Ratings**

| Parameter                                                                                                  | Symbol    | Value | Unit             |
|------------------------------------------------------------------------------------------------------------|-----------|-------|------------------|
| Drain Source voltage slope<br>$V_{DS} = 480 \text{ V}, I_D = 20.7 \text{ A}, T_j = 125^\circ\text{C}$      | $dv/dt$   | 80    | V/ns             |
| Maximum diode commutation speed<br>$V_{DS} = 480 \text{ V}, I_D = 20.7 \text{ A}, T_j = 125^\circ\text{C}$ | $di_F/dt$ | 900   | A/ $\mu\text{s}$ |

**Thermal Characteristics**

| Parameter                                                                    | Symbol       | Values |      |      | Unit             |
|------------------------------------------------------------------------------|--------------|--------|------|------|------------------|
|                                                                              |              | min.   | typ. | max. |                  |
| Thermal resistance, junction - case                                          | $R_{thJC}$   | -      | -    | 0.6  | K/W              |
| Thermal resistance, junction - ambient, leaded                               | $R_{thJA}$   | -      | -    | 62   |                  |
| Soldering temperature, wavesoldering<br>1.6 mm (0.063 in.) from case for 10s | $T_{solder}$ | -      | -    | 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 | $V_{(BR)DS}$  | $V_{GS}=0\text{V}, I_D=20\text{A}$                                                            | -      | 700          | -         |               |
| Gate threshold voltage                   | $V_{GS(th)}$  | $I_D=1000\mu\text{A}, V_{GS}=V_{DS}$                                                          | 3      | 4            | 5         |               |
| 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>- | 2.1<br>1700  | -<br>-    | $\mu\text{A}$ |
| Gate-source leakage current              | $I_{GSS}$     | $V_{GS}=20\text{V}, V_{DS}=0\text{V}$                                                         | -      | -            | 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>$T_j=150^\circ\text{C}$   | -<br>- | 0.19<br>0.51 | 0.22<br>- | $\Omega$      |
| Gate input resistance                    | $R_G$         | $f=1\text{MHz}, \text{open Drain}$                                                            | -      | 0.54         | -         |               |

**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>$I_D = 13.1\text{A}$                        | -      | 17.5 | -    | S    |
| Input capacitance                                             | $C_{iss}$    | $V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,<br>$f = 1\text{MHz}$                            | -      | 2400 | -    | pF   |
| Output capacitance                                            | $C_{oss}$    |                                                                                                | -      | 780  | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |                                                                                                | -      | 50   | -    |      |
| Effective output capacitance, <sup>2)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0\text{V}$ ,<br>$V_{DS} = 0\text{V to } 480\text{V}$                                 | -      | 83   | -    | pF   |
| Effective output capacitance, <sup>3)</sup><br>time related   | $C_{o(tr)}$  |                                                                                                | -      | 160  | -    |      |
| Turn-on delay time                                            | $t_{d(on)}$  | $V_{DD} = 380\text{V}$ , $V_{GS} = 0/10\text{V}$ ,<br>$I_D = 20.7\text{A}$ , $R_G = 3.6\Omega$ | -      | 12   | -    | ns   |
| Rise time                                                     | $t_r$        |                                                                                                | -      | 15   | -    |      |
| Turn-off delay time                                           | $t_{d(off)}$ |                                                                                                | -      | 59   | -    |      |
| Fall time                                                     | $t_f$        |                                                                                                | -      | 6.4  | -    |      |

**Gate Charge Characteristics**

|                       |                 |                                                                                       |   |    |     |    |
|-----------------------|-----------------|---------------------------------------------------------------------------------------|---|----|-----|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$                                         | - | 15 | -   | nC |
| Gate to drain charge  | $Q_{gd}$        |                                                                                       | - | 54 | -   |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$ ,<br>$V_{GS} = 0\text{ to } 10\text{V}$ | - | 95 | 124 |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 480\text{V}$ , $I_D = 20.7\text{A}$                                         | - | 7  | -   | 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>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

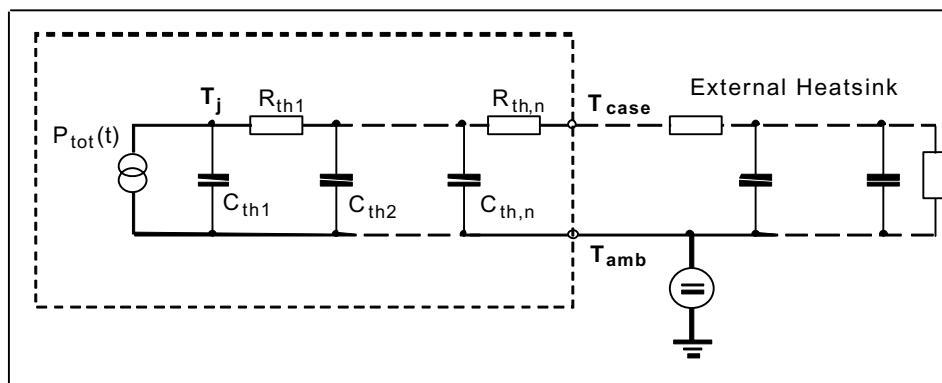
<sup>3</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**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      | $I_S$        | $T_C=25^{\circ}\text{C}$                                             | -      | -    | 20.7 | A                      |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                                                      | -      | -    | 52   |                        |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0\text{V}$ , $I_F=I_S$                                       | -      | 1    | 1.2  | V                      |
| Reverse recovery time                         | $t_{rr}$     | $V_R=480\text{V}$ , $I_F=I_S$ ,<br>$di_F/dt=100\text{A}/\mu\text{s}$ | -      | 150  | -    | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     |                                                                      | -      | 1    | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                                                      | -      | 13   | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ |                                                                      | -      | 1400 | -    | $\text{A}/\mu\text{s}$ |

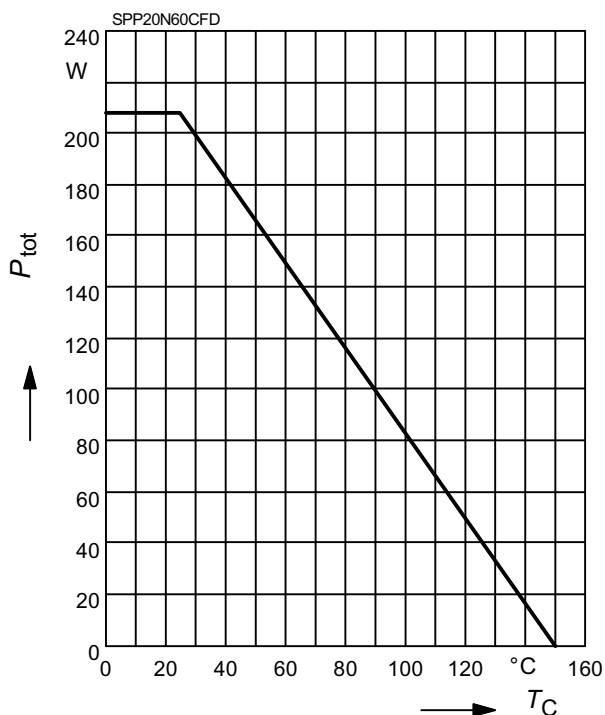
**Typical Transient Thermal Characteristics**

| Symbol             | Value    | Unit | Symbol              | Value     | Unit |
|--------------------|----------|------|---------------------|-----------|------|
|                    | typ.     |      |                     | typ.      |      |
| Thermal resistance |          |      | Thermal capacitance |           |      |
| $R_{th1}$          | 0.007686 | K/W  | $C_{th1}$           | 0.0003764 | Ws/K |
| $R_{th2}$          | 0.015    |      | $C_{th2}$           | 0.001412  |      |
| $R_{th3}$          | 0.029    |      | $C_{th3}$           | 0.001932  |      |
| $R_{th4}$          | 0.114    |      | $C_{th4}$           | 0.005299  |      |
| $R_{th5}$          | 0.136    |      | $C_{th5}$           | 0.012     |      |
| $R_{th6}$          | 0.059    |      | $C_{th6}$           | 0.091     |      |



### 1 Power dissipation

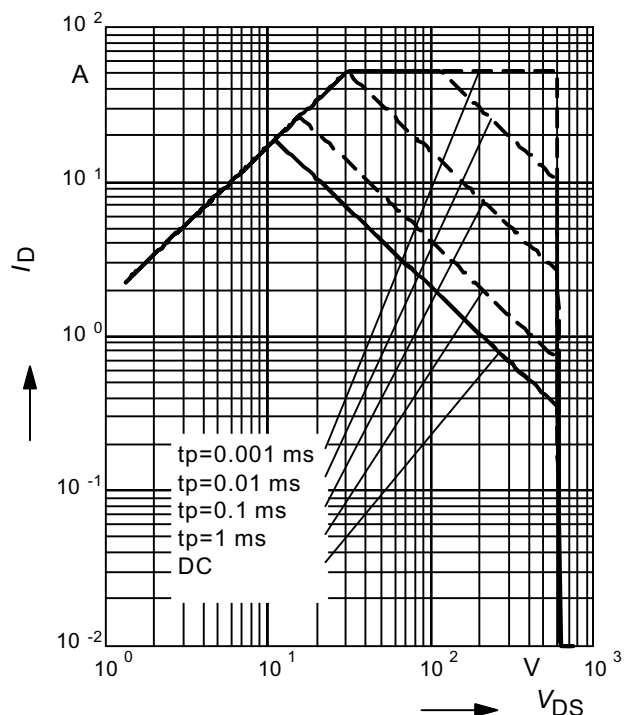
$$P_{\text{tot}} = f(T_C)$$



### 2 Safe operating area

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

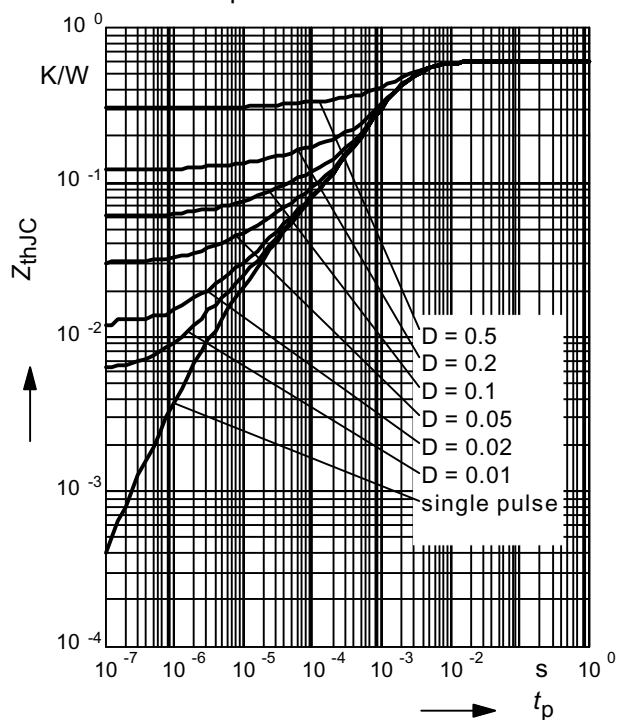
parameter:  $D = 0$ ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

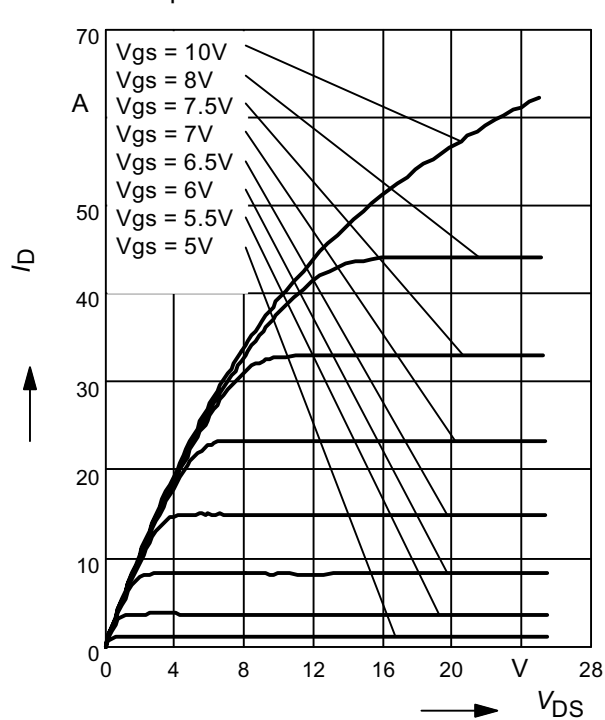
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

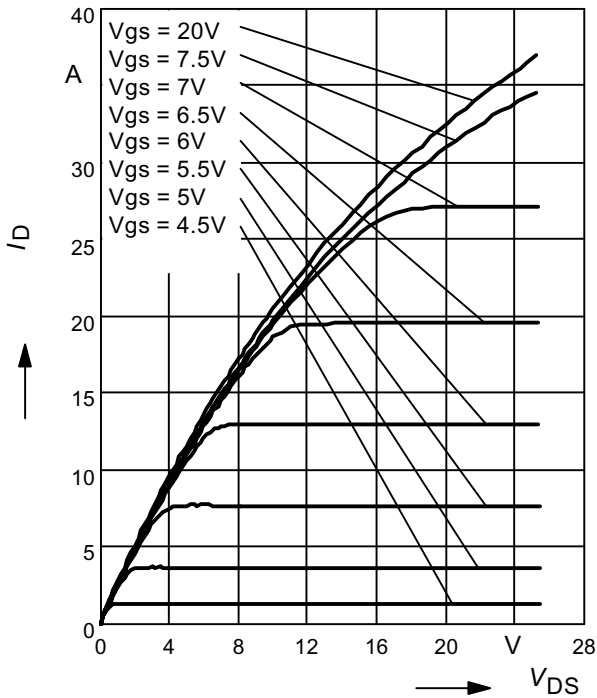
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



**5 Typ. output characteristic**

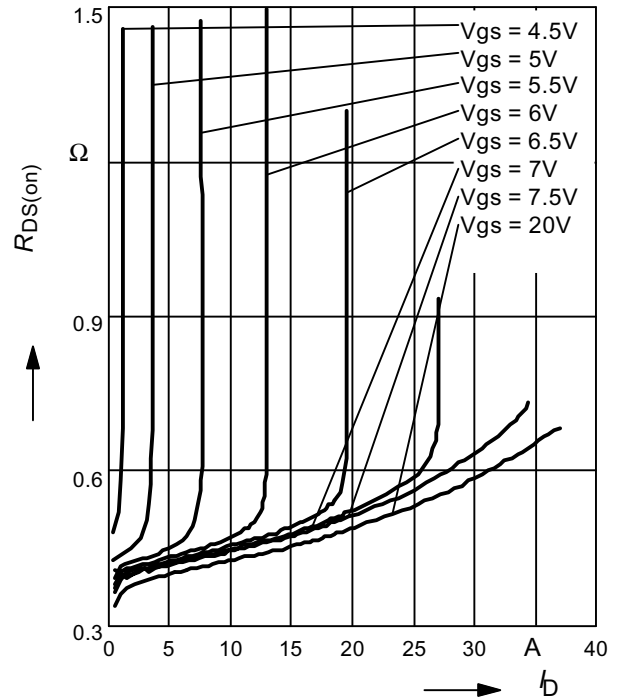
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

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


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

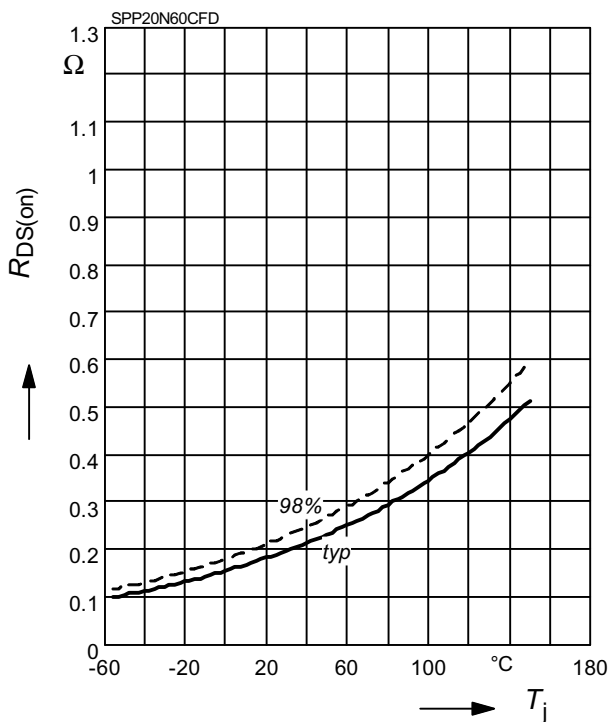
$$R_{DS(on)} = f(I_D)$$

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


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

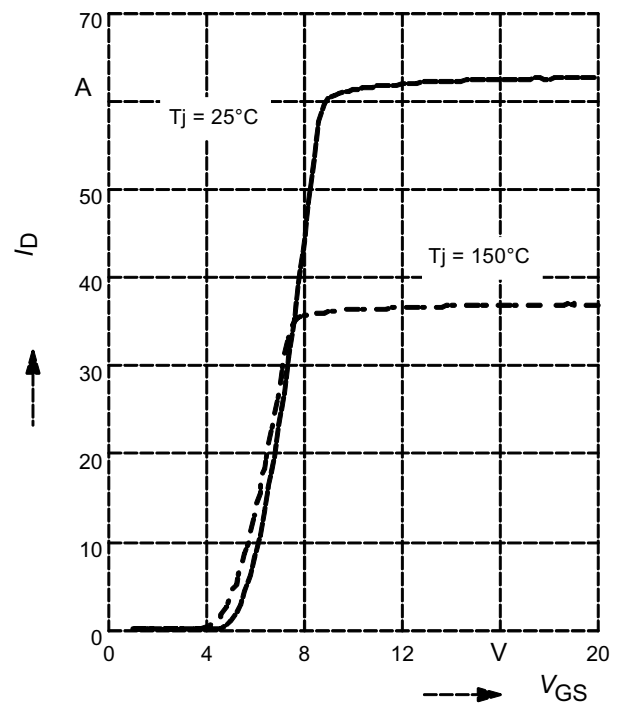
$$R_{DS(on)} = f(T_j)$$

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


**8 Typ. transfer characteristics**

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

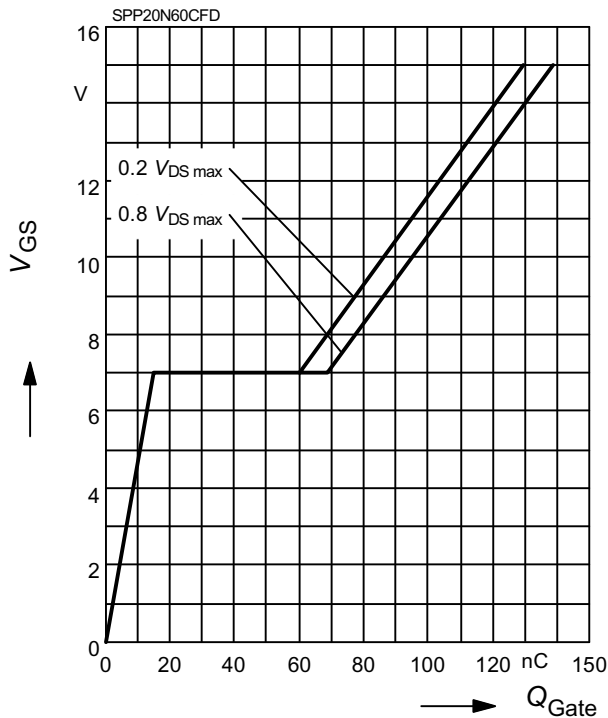
parameter:  $t_p = 10 \mu\text{s}$



### 9 Typ. gate charge

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

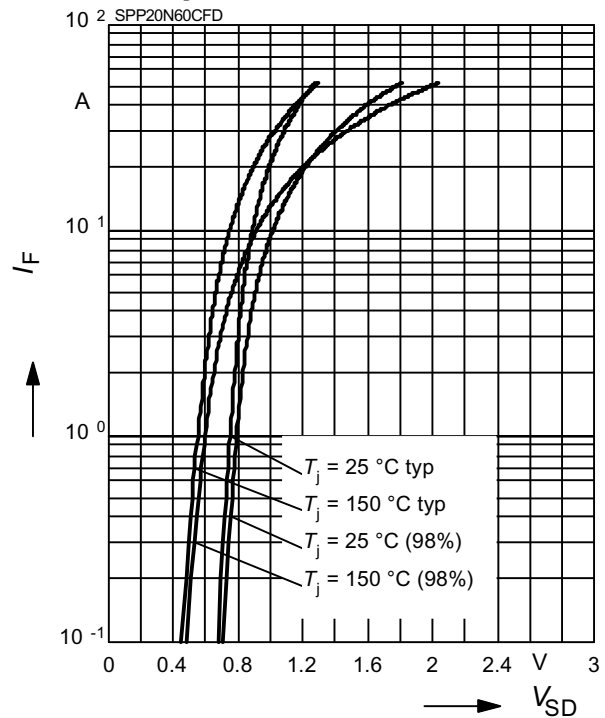
parameter:  $I_D = 20.7 \text{ A}$  pulsed



### 10 Forward characteristics of body diode

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

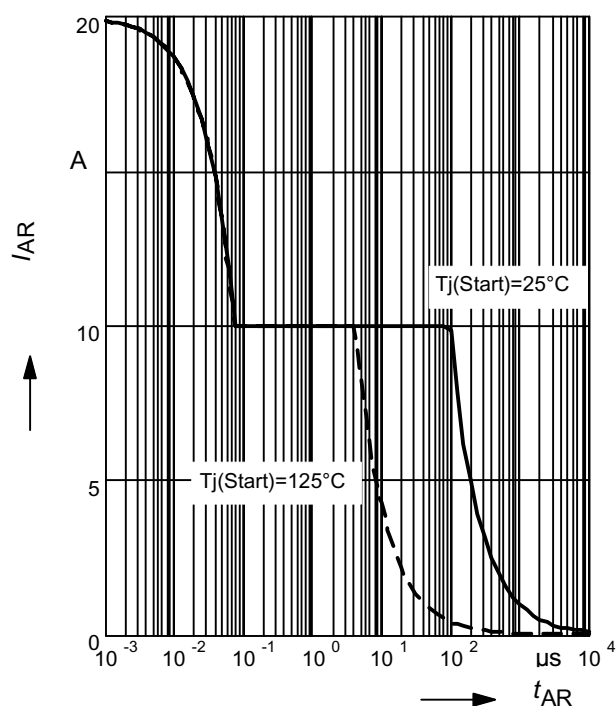
parameter:  $T_j, t_p = 10 \mu\text{s}$



### 11 Avalanche SOA

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

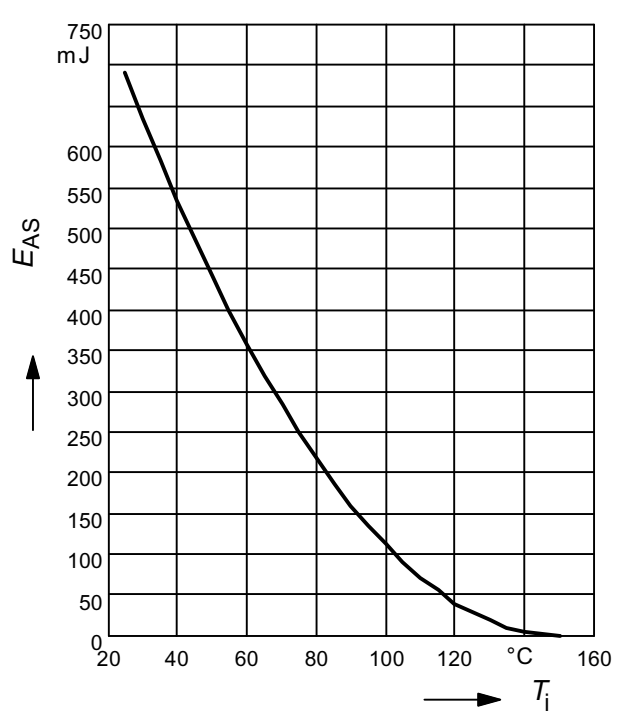
par.:  $T_j \leq 150 \text{ °C}$



### 12 Avalanche energy

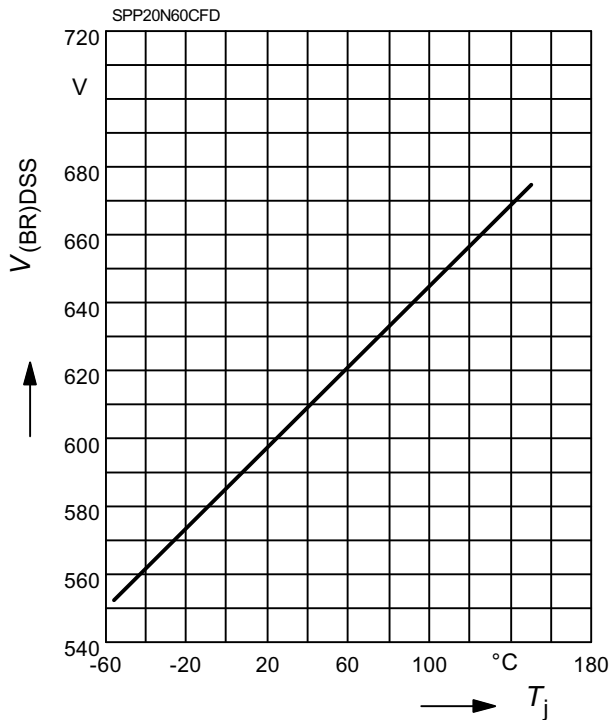
$$E_{AS} = f(T_j)$$

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



### 13 Drain-source breakdown voltage

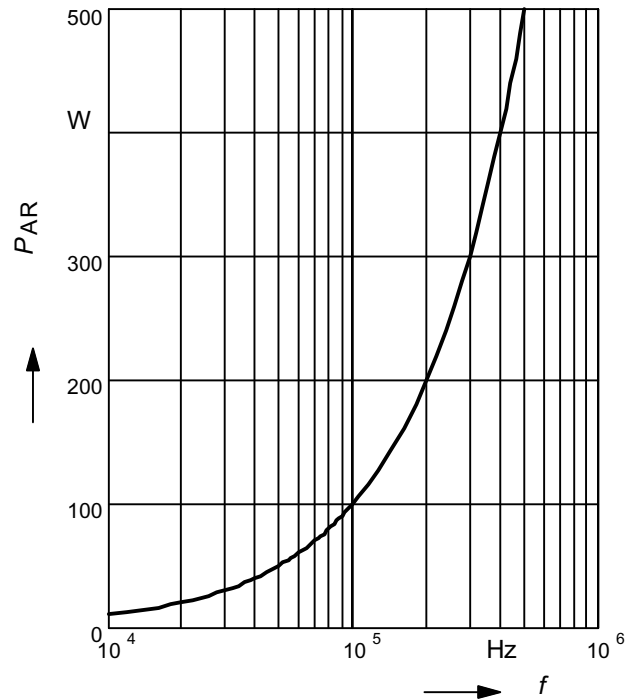
$$V_{(BR)DSS} = f(T_j)$$



### 14 Avalanche power losses

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

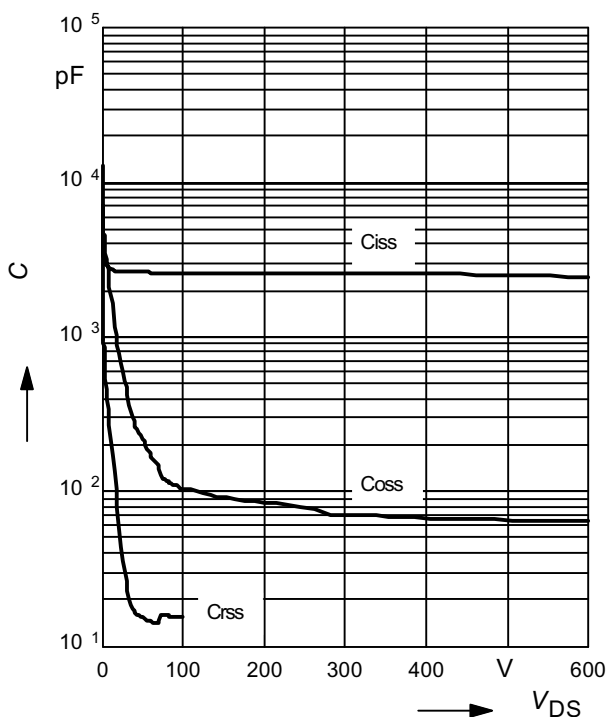
parameter:  $E_{AR}=1\text{mJ}$



### 15 Typ. capacitances

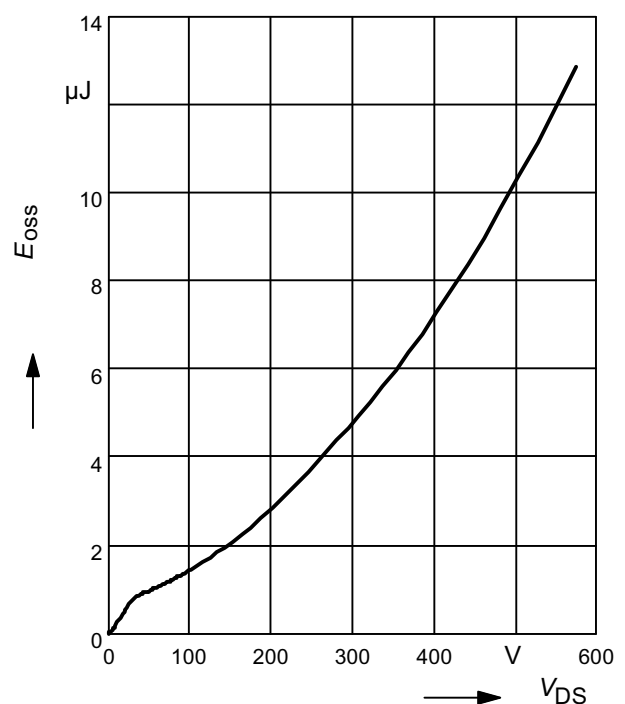
$$C = f(V_{DS})$$

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



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

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

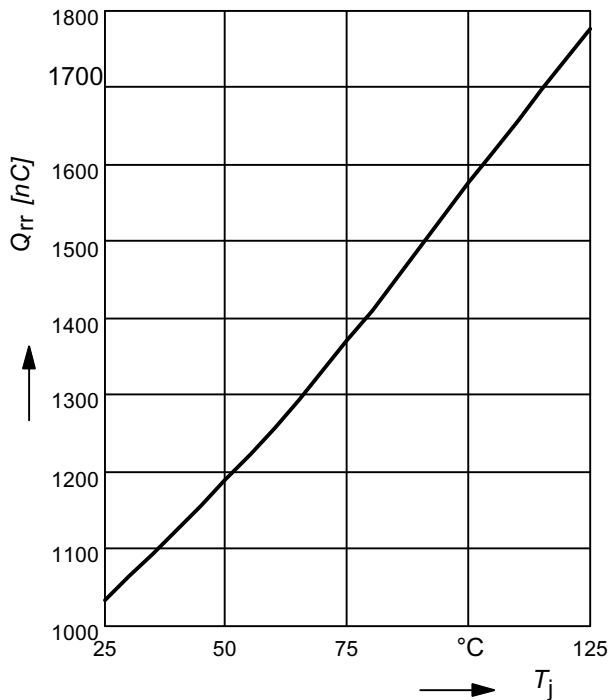




**17 Typ. reverse recovery charge**

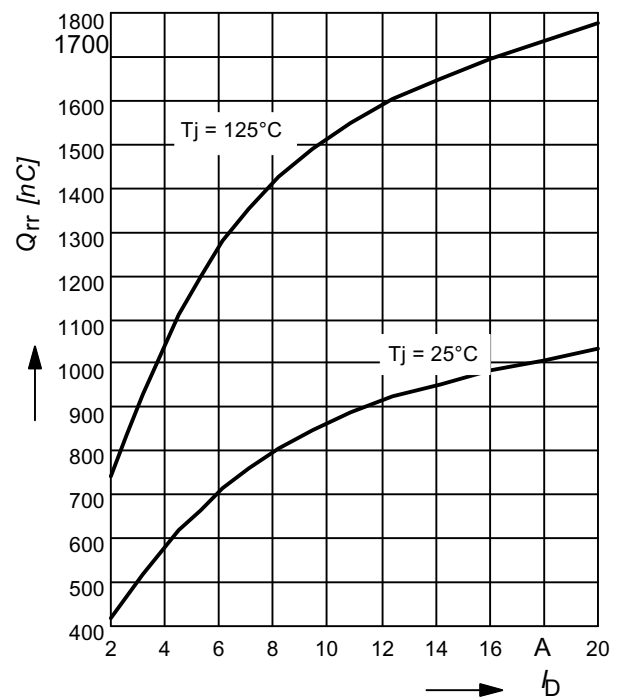
$$Q_{rr} = f(T_j)$$

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


**18 Typ. reverse recovery charge**

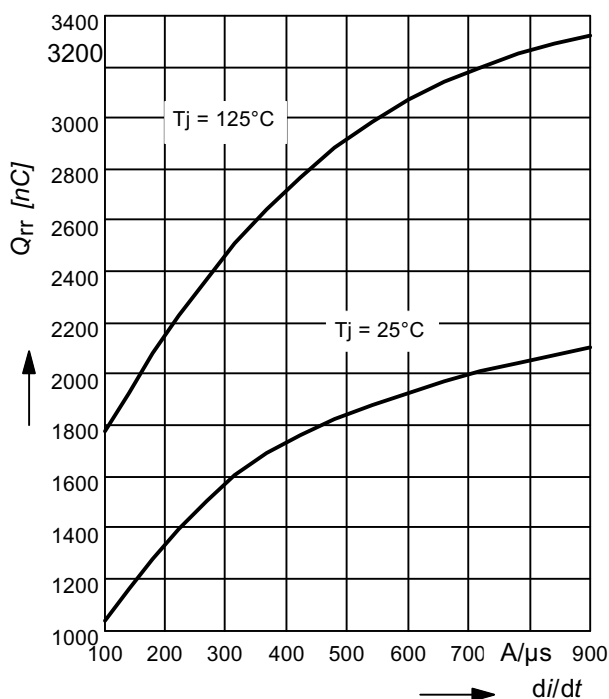
$$Q_{rr} = f(I_D)$$

parameter:  $di/dt = 100 \text{ A/}\mu\text{s}$

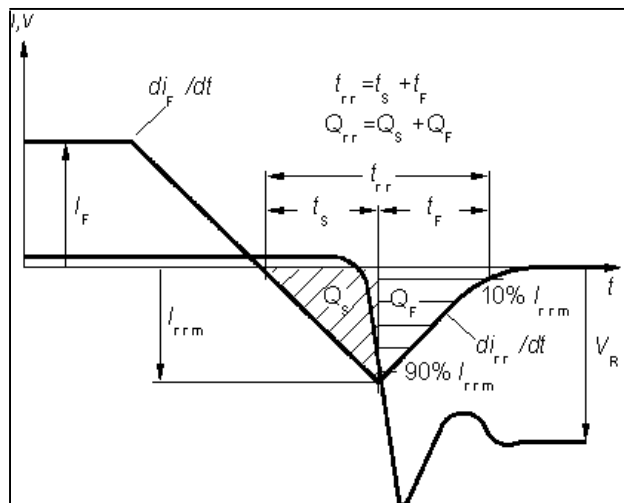

**19 Typ. reverse recovery charge**

$$Q_{rr} = f(di/dt)$$

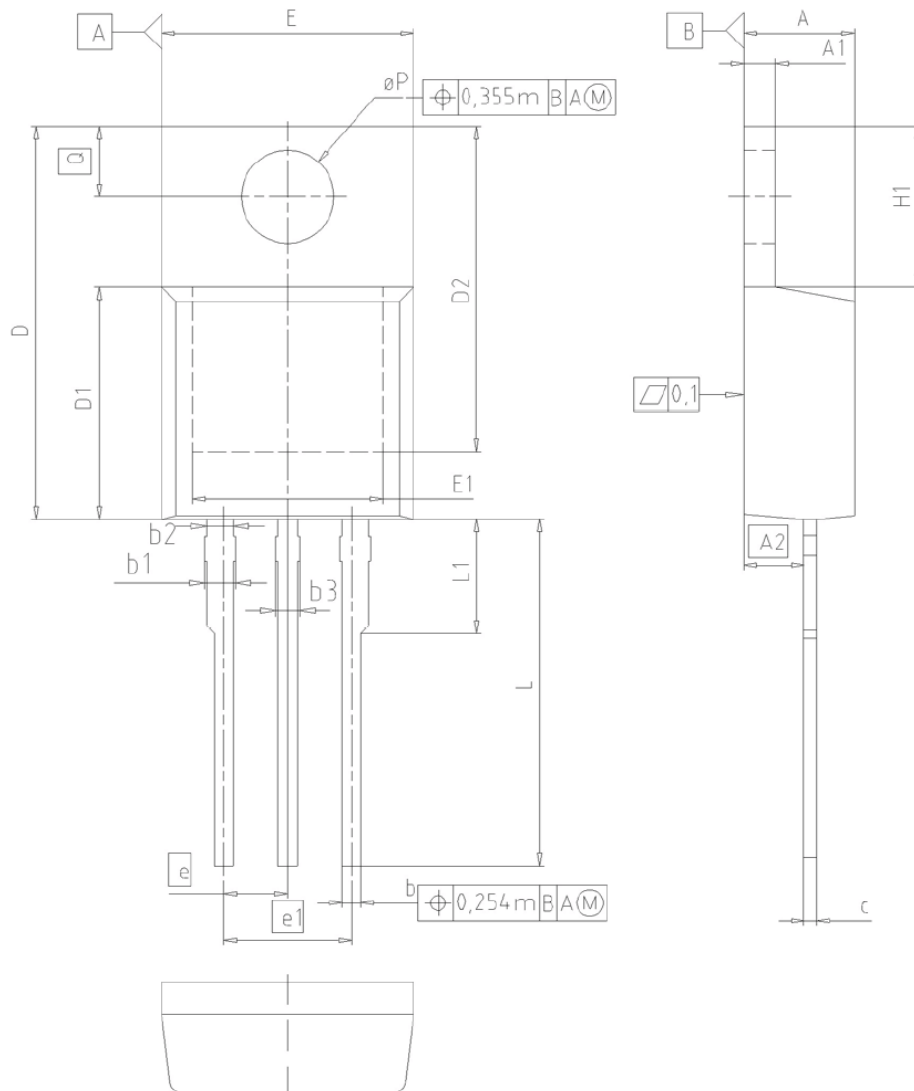
parameter:  $I_D = 20.7 \text{ A}$



# Definition of diodes switching characteristics



PG-TO-220-3-1, PG-TO220-3-21



| 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 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>DOCUMENT NO.</b><br>Z8B00003318                                                                                  |
| <b>SCALE</b><br>0 2.5 5mm                                                                                           |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>23-08-2007                                                                                     |
| <b>REVISION</b><br>05                                                                                               |

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