

## CoolMOS™ Power Transistor

### Features

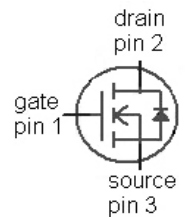
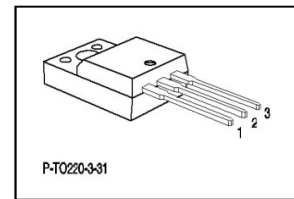
- New revolutionary high voltage technology
- Intrinsic fast-recovery body diode
- Extremely low reverse recovery charge
- Ultra low gate charge
- Extreme  $dv/dt$  rated
- High peak current capability
- Periodic avalanche rated
- Qualified for industrial grade applications according to JEDEC<sup>0)</sup>
- Pb-free lead plating; RoHS compliant

| Type        | Package       | Ordering Code | Marking  |
|-------------|---------------|---------------|----------|
| SPA20N60CFD | PG-TO220-3-31 | SP000216361   | 20N60CFD |

### Product Summary

|                  |      |          |
|------------------|------|----------|
| $V_{DS}$         | 600  | V        |
| $R_{DS(on),max}$ | 0.22 | $\Omega$ |
| $I_D^{1)}$       | 20.7 | A        |

PG-TO220-3-31



**Maximum ratings**, at  $T_J=25\text{ °C}$ , unless otherwise specified

| Parameter                                      | Symbol            | Conditions                                                              | Value        | Unit       |
|------------------------------------------------|-------------------|-------------------------------------------------------------------------|--------------|------------|
| Continuous drain current <sup>1)</sup>         | $I_D$             | $T_C=25\text{ °C}$                                                      | 20.7         | A          |
|                                                |                   | $T_C=100\text{ °C}$                                                     | 13.1         |            |
| Pulsed drain current <sup>2)</sup>             | $I_{D,pulse}$     | $T_C=25\text{ °C}$                                                      | 52           |            |
| Avalanche energy, single pulse                 | $E_{AS}$          | $I_D=10\text{ A}$ , $V_{DD}=50\text{ V}$                                | 690          | mJ         |
| Avalanche energy, repetitive $t_{AR}^{2),3)}$  | $E_{AR}$          | $I_D=20\text{ A}$ , $V_{DD}=50\text{ V}$                                | 1            |            |
| Avalanche current, repetitive $t_{AR}^{2),3)}$ | $I_{AR}$          |                                                                         | 20           | A          |
| Drain source voltage slope                     | $dv/dt$           | $I_D=20.7\text{ A}$ ,<br>$V_{DS}=480\text{ V}$ ,<br>$T_J=125\text{ °C}$ | 80           | V/ns       |
| Reverse diode $dv/dt$                          | $dv/dt$           | $I_S=20.7\text{ A}$ ,<br>$V_{DS}=480\text{ V}$ ,<br>$T_J=125\text{ °C}$ | 40           | V/ns       |
| Maximum diode commutation speed                | $di/dt$           |                                                                         | 900          | A/ $\mu$ s |
| Gate source voltage                            | $V_{GS}$          | static                                                                  | $\pm 20$     | V          |
|                                                |                   | AC ( $f>1\text{ Hz}$ )                                                  | $\pm 30$     |            |
| Power dissipation                              | $P_{tot}$         | $T_C=25\text{ °C}$                                                      | 35           | W          |
| Operating and storage temperature              | $T_J$ , $T_{stg}$ |                                                                         | -55 ... +150 | °C         |

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

**Thermal characteristics**

|                                        |            |                                       |   |   |     |     |
|----------------------------------------|------------|---------------------------------------|---|---|-----|-----|
| Thermal resistance, junction - case    | $R_{thJC}$ |                                       | - | - | 3.6 | K/W |
| Thermal resistance, junction - ambient | $R_{thJA}$ | leaded                                | - | - | 62  |     |
| Soldering temperature, wave soldering  | $T_{sold}$ | 1.6 mm (0.063 in.) from case for 10 s | - | - | 260 | °C  |

**Electrical characteristics, at  $T_j=25\text{ °C}$ , unless otherwise specified**
**Static characteristics**

|                                  |               |                                                                   |     |      |      |               |
|----------------------------------|---------------|-------------------------------------------------------------------|-----|------|------|---------------|
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | $V_{GS}=0\text{ V}$ , $I_D=250\text{ }\mu\text{A}$                | 600 | -    | -    | V             |
| Avalanche breakdown voltage      | $V_{(BR)DS}$  | $V_{GS}=0\text{ V}$ , $I_D=20\text{ A}$                           | -   | 700  | -    |               |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}$ , $I_D=1000\mu\text{A}$                           | 3   | 4    | 5    |               |
| Zero gate voltage drain current  | $I_{DSS}$     | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=25\text{ °C}$  | -   | 2.1  | -    | $\mu\text{A}$ |
|                                  |               | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ , $T_j=150\text{ °C}$ | -   | 1700 | -    |               |
| Gate-source leakage current      | $I_{GSS}$     | $V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$                        | -   | -    | 100  | nA            |
| Drain-source on-state resistance | $R_{DS(on)}$  | $V_{GS}=10\text{ V}$ , $I_D=13.1\text{ A}$ , $T_j=25\text{ °C}$   | -   | 0.19 | 0.22 | $\Omega$      |
|                                  |               | $V_{GS}=10\text{ V}$ , $I_D=13.1\text{ A}$ , $T_j=150\text{ °C}$  | -   | 0.43 | -    |               |
| Gate resistance                  | $R_G$         | $f=1\text{ MHz}$ , open drain                                     | -   | 0.54 | -    |               |
| Transconductance                 | $g_{fs}$      | $ V_{DS} >2 I_D R_{DS(on)max}$ , $I_D=13.1\text{ A}$              | -   | 17.5 | -    | S             |

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

**Dynamic characteristics**

|                                                            |              |                                                                                         |   |      |   |    |
|------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------|---|------|---|----|
| 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, energy related <sup>4)</sup> | $C_{o(er)}$  | $V_{GS}=0\text{ V}, V_{DS}=0\text{ V}$<br>to 480 V                                      | - | 83   | - |    |
| Effective output capacitance, time related <sup>5)</sup>   | $C_{o(tr)}$  |                                                                                         | - | 160  | - |    |
| Turn-on delay time                                         | $t_{d(on)}$  | $V_{DD}=380\text{ V},$<br>$V_{GS}=10\text{ V}, I_D=20.7\text{ A},$<br>$R_G=3.6\ \Omega$ | - | 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 | $Q_{gs}$      | $V_{DD}=480\text{ V},$<br>$I_D=20.7\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 15  | -   | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                                    | - | 54  | -   |    |
| Gate charge total     | $Q_g$         |                                                                                    | - | 95  | 124 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                                    | - | 7.0 | -   | V  |

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

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

<sup>2)</sup> Pulse width  $t_p$  limited by  $T_{j,max}$

<sup>3)</sup> Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV}=E_{AR}*f$ .

<sup>4)</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>5)</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%  $V_{DSS}$ .

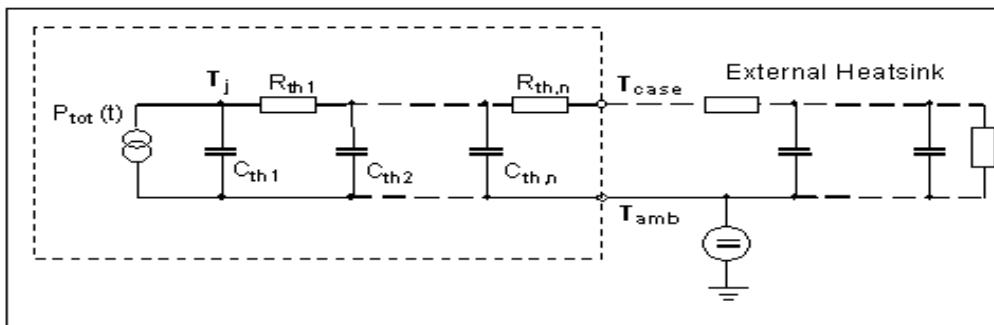
| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

**Reverse Diode**

|                                                |               |                                                               |   |     |      |               |
|------------------------------------------------|---------------|---------------------------------------------------------------|---|-----|------|---------------|
| Diode continuous forward current <sup>1)</sup> | $I_S$         | $T_C=25\text{ °C}$                                            | - | -   | 20.7 | A             |
| Diode pulse current <sup>2)</sup>              | $I_{S,pulse}$ |                                                               | - | -   | 52   |               |
| Diode forward voltage                          | $V_{SD}$      | $V_{GS}=0\text{ V}, I_F=20.7\text{ A}, T_J=25\text{ °C}$      | - | 1.0 | 1.2  | V             |
| Reverse recovery time                          | $t_{rr}$      | $V_R=480\text{ V}, I_F=I_S, di_F/dt=100\text{ A/}\mu\text{s}$ | - | 150 | -    | ns            |
| Reverse recovery charge                        | $Q_{rr}$      |                                                               | - | 1   | -    | $\mu\text{C}$ |
| Peak reverse recovery current                  | $I_{rrm}$     |                                                               | - | 13  | -    | A             |

**Typical Transient Thermal Characteristics**

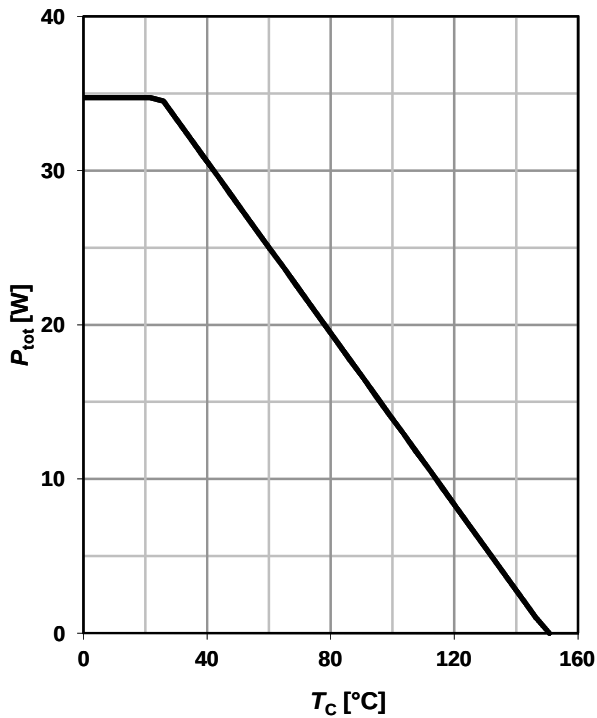
| Symbol    | Value   | Unit | Symbol    | Value    | Unit |
|-----------|---------|------|-----------|----------|------|
|           | typ.    |      |           | typ.     |      |
| $R_{th1}$ | 0.00862 | K/W  | $C_{th1}$ | 0.000205 | Ws/K |
| $R_{th2}$ | 0.0471  |      | $C_{th2}$ | 0.00198  |      |
| $R_{th3}$ | 0.119   |      | $C_{th3}$ | 0.0068   |      |
| $R_{th4}$ | 0.476   |      | $C_{th4}$ | 0.0482   |      |
| $R_{th5}$ | 1.57    |      | $C_{th5}$ | 0.957    |      |
|           |         |      | $C_{th6}$ | 0.1      |      |



<sup>5)</sup>  $C_{th6}$  models the additional heat capacitance of the package in case of non-ideal cooling. It is not needed if  $R_{thCA}=0\text{ K/W}$ .

## 1 Power dissipation

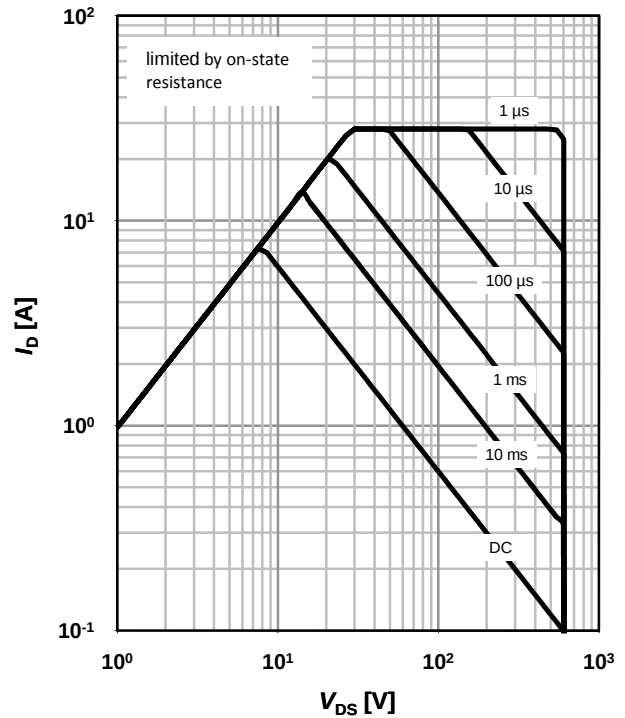
$$P_{TOT}=f(T_C)$$



## 2 Safe operating area

$$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$$

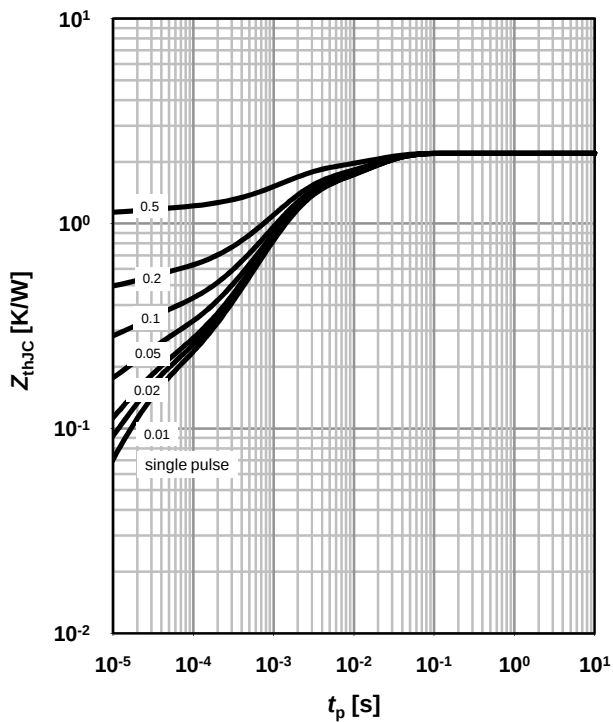
parameter:  $t_p$



## 3 Max. transient thermal impedance

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

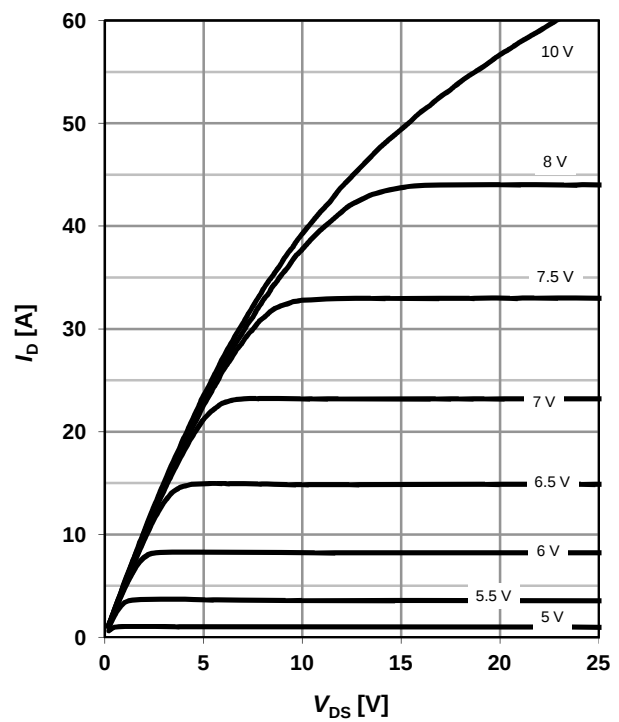
parameter:  $D=t_p/T$



## 4 Typ. output characteristics

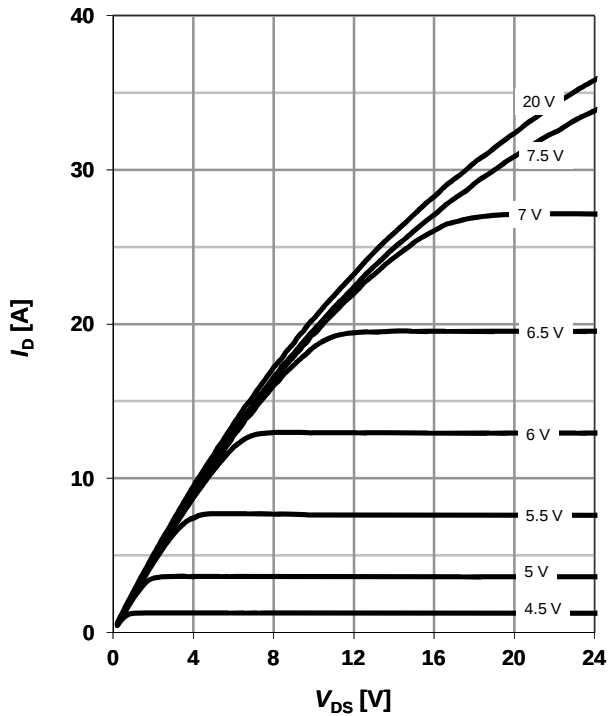
$$I_D=f(V_{DS}); T_J=25\text{ °C}$$

parameter:  $V_{GS}$



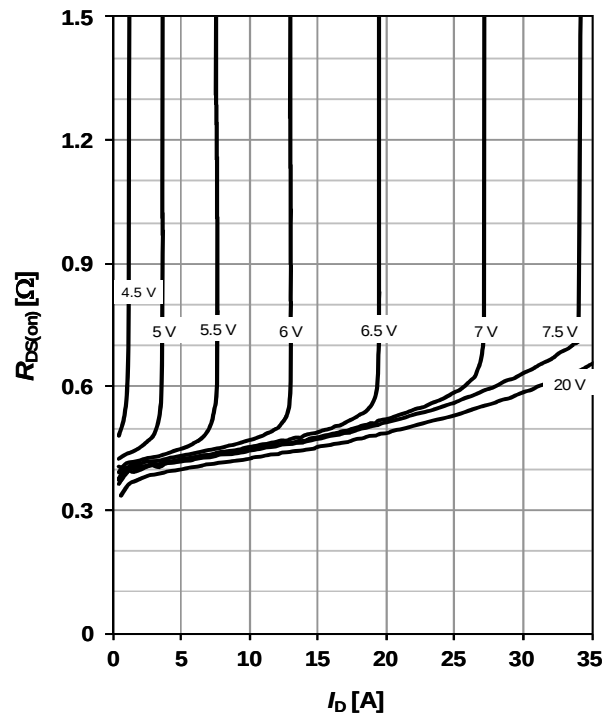
### 5 Typ. output characteristics

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

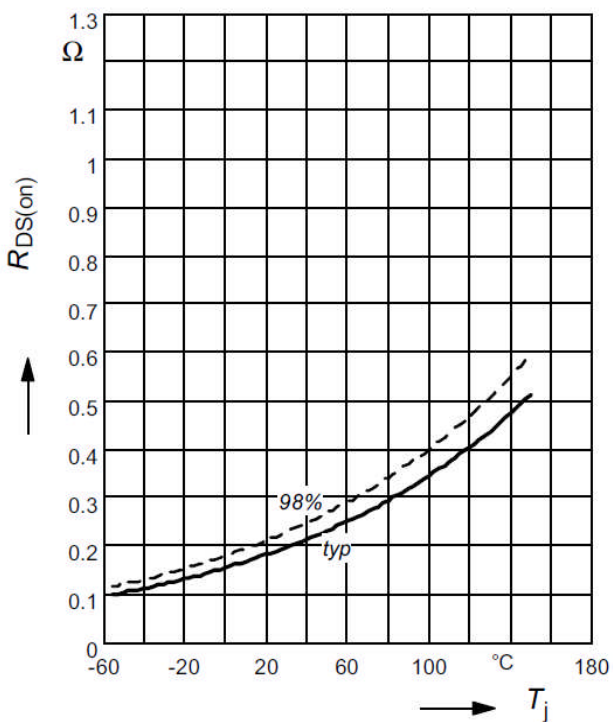
parameter:  $V_{GS}$ 


### 6 Typ. drain-source on-state resistance

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

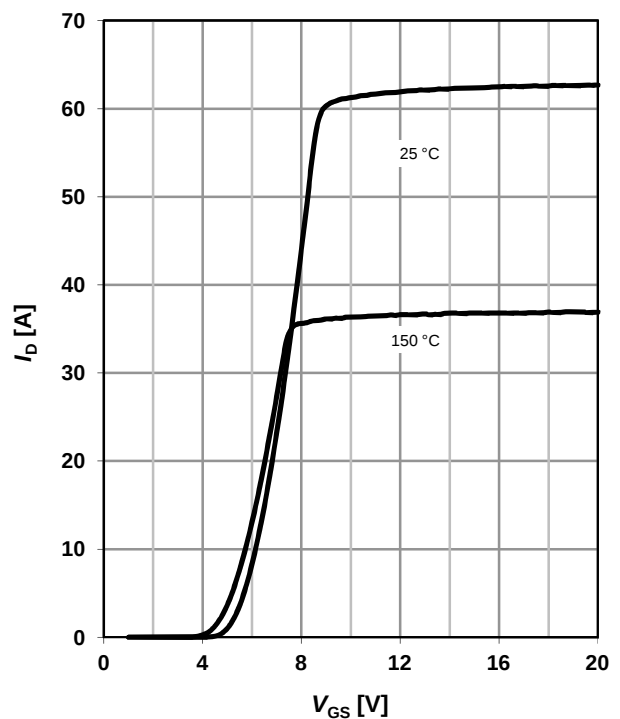
parameter:  $V_{GS}$ 


### 7 Drain-source on-state resistance

 $R_{DS(on)} = f(T_j); I_D = 13.1\text{ A}; V_{GS} = 10\text{ V}$ 


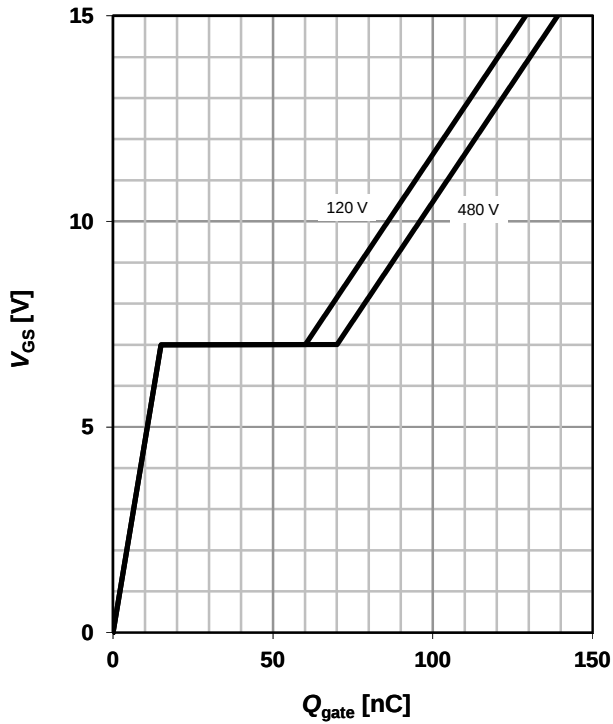
### 8 Typ. transfer characteristics

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

parameter:  $T_j$ 


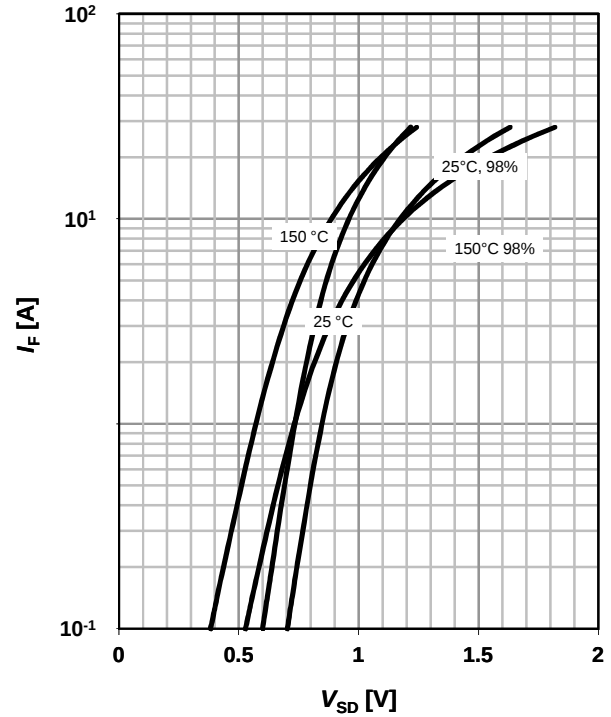
### 9 Typ. gate charge

 $V_{GS}=f(Q_{gate}); I_D=20.7 \text{ A pulsed}$ 

parameter:  $V_{DD}$ 


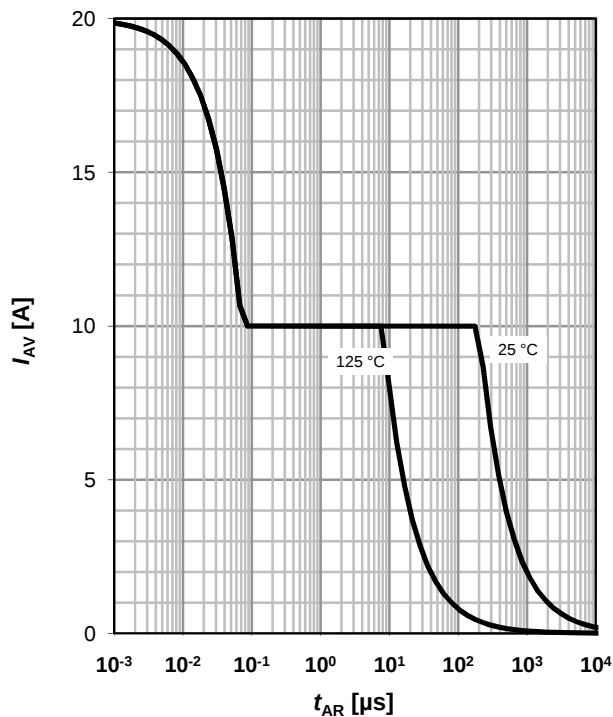
### 10 Forward characteristics of reverse diode

 $I_F=f(V_{SD})$ 

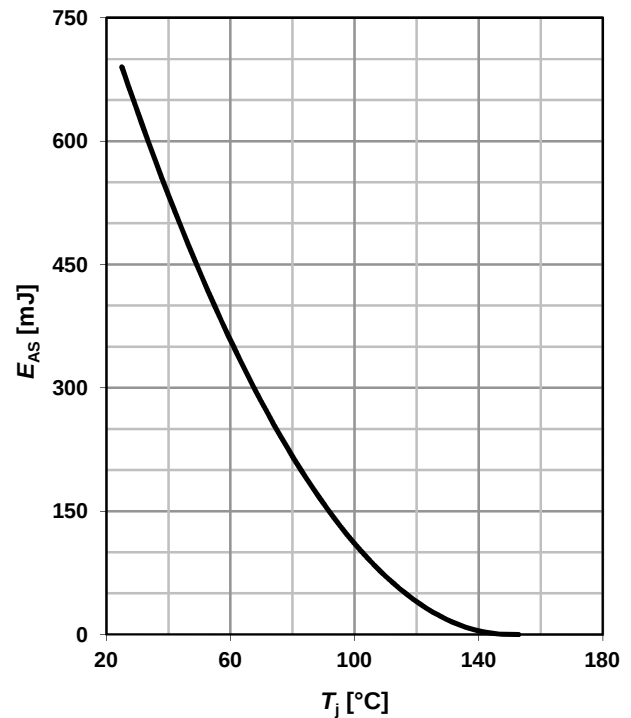
parameter:  $T_j$ 


### 11 Avalanche SOA

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

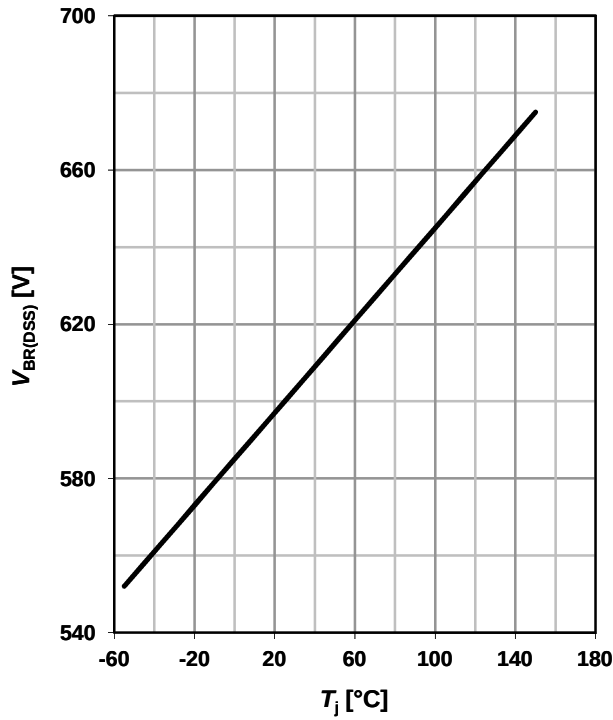
parameter:  $T_{j(start)}$ 


### 12 Avalanche energy

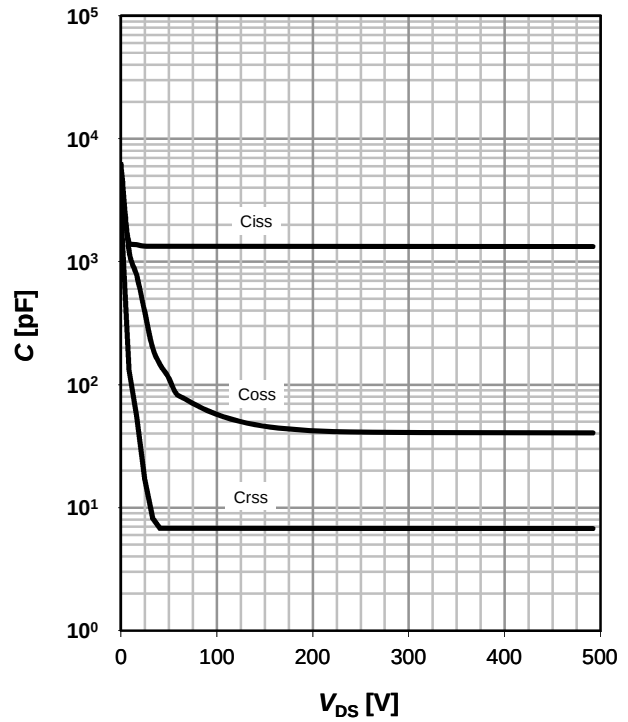
 $E_{AS}=f(T_j); I_D=10 \text{ A}; V_{DD}=50 \text{ V}$ 


**13 Drain-source breakdown voltage**

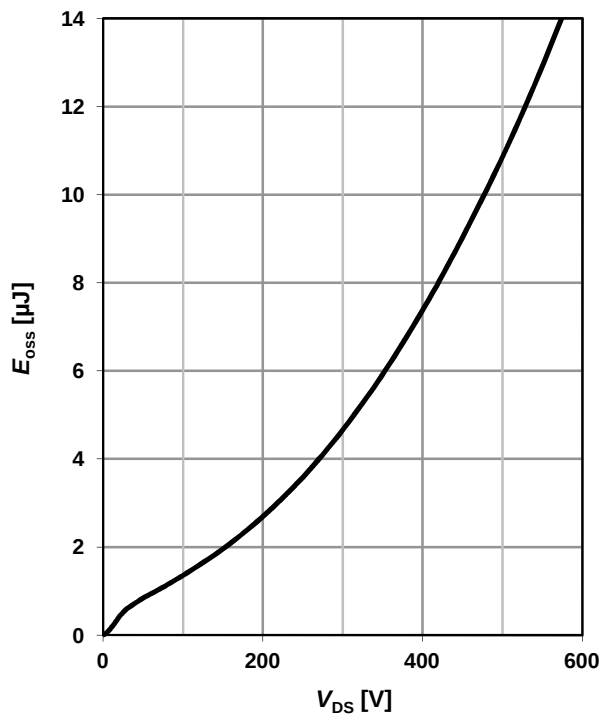
$$V_{BR(DSS)} = f(T_j); I_D = 10 \text{ mA}$$


**14 Typ. capacitances**

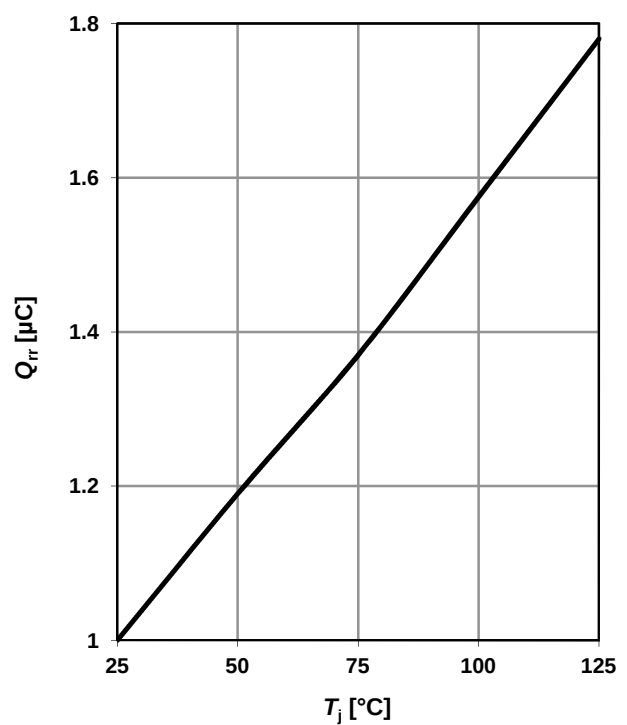
$$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$$


**15 Typ.  $C_{oss}$  stored energy**

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


**16 Typ. reverse recovery charge**

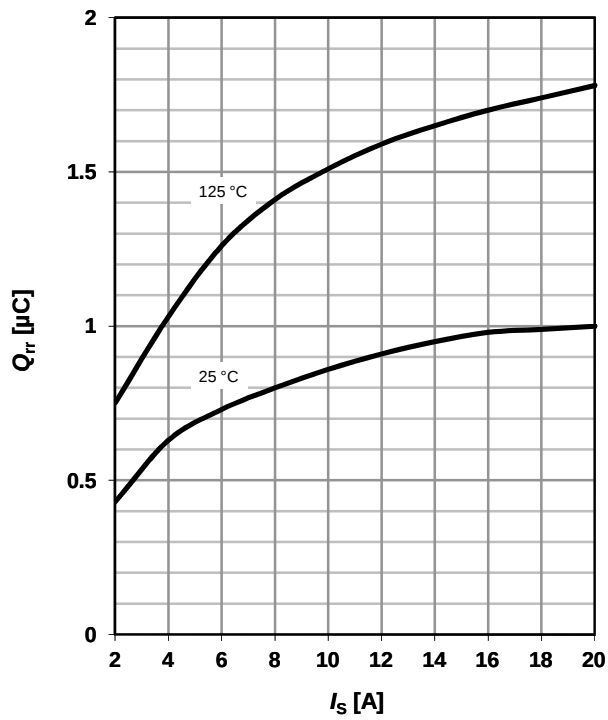
$$Q_r = f(T_j); I_S = 20.7 \text{ A}$$



**17 Typ. reverse recovery charge**

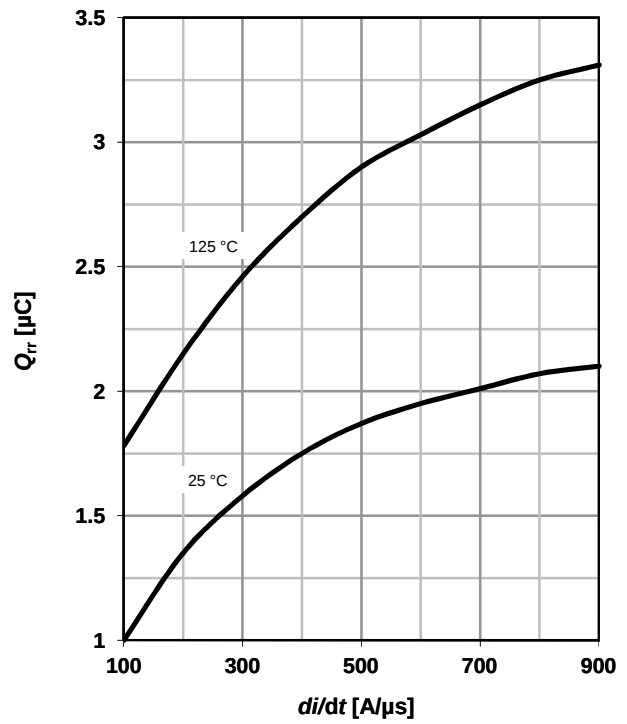
$$Q_{rr} = f(I_S); \, di/dt = 100 \text{ A}/\mu\text{s}$$

parameter:  $T_j$

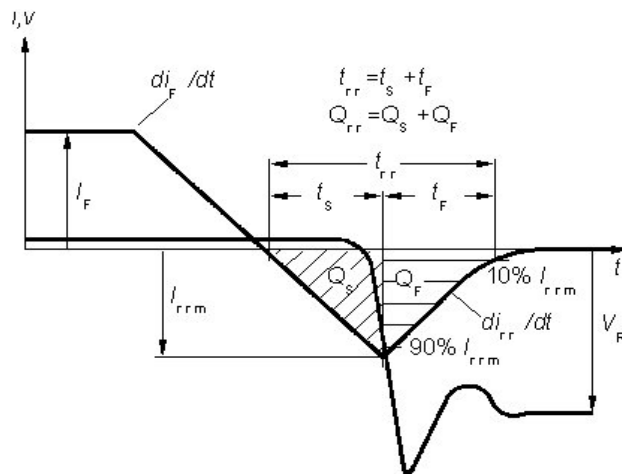

**18 Typ. reverse recovery charge**

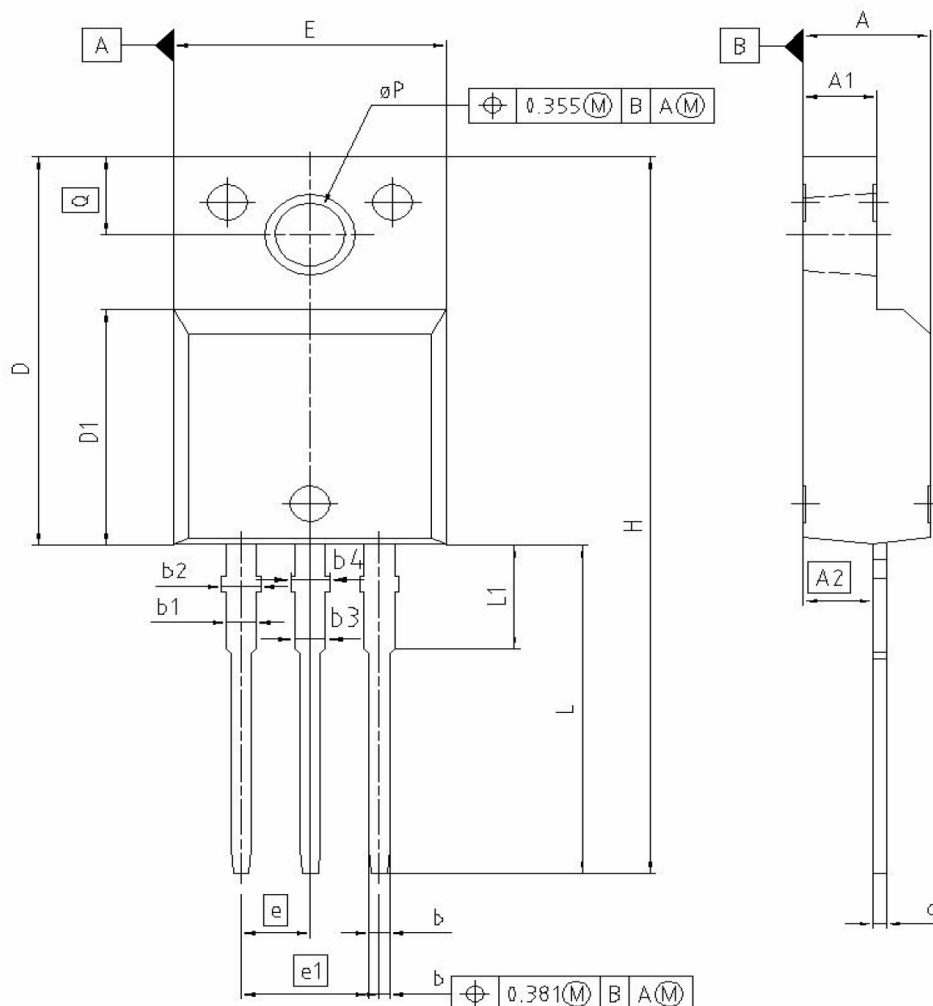
$$Q_{rr} = f(di/dt); \, I_D = 20.7 \text{ A}$$

parameter:  $T_j$

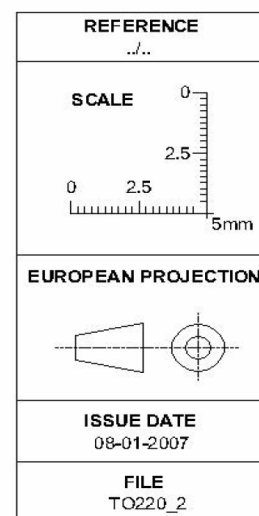


### Definition of diode switching characteristics



**PG-TO220-3-31: Outline**


| 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 |
| pP  | 2.95        | 3.20  | 0.116  | 0.126 |
| Q   | 3.15        | 3.50  | 0.124  | 0.138 |



Dimensions in mm

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