

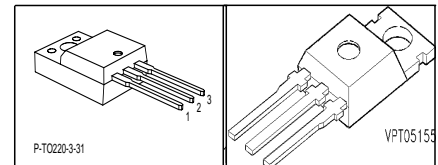
## Cool MOS™ Power Transistor

### Feature

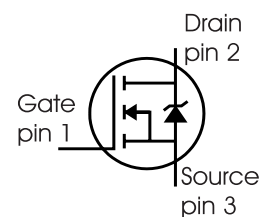
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved transconductance
- PG-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>0)</sup> for target applications

|              |     |          |
|--------------|-----|----------|
| $V_{DS}$     | 800 | V        |
| $R_{DS(on)}$ | 1.3 | $\Omega$ |
| $I_D$        | 4   | A        |

PG-TO220-3-31 PG-TO220



| Type       | Package       | Ordering Code | Marking |
|------------|---------------|---------------|---------|
| SPP04N80C3 | PG-TO220      | Q67040-S4433  | 04N80C3 |
| SPA04N80C3 | PG-TO220-3-31 | SP000216300   | 04N80C3 |



### Maximum Ratings

| Parameter  | Symbol              | Value      |                                      | Unit             |
|--|---------------------|------------|--------------------------------------|------------------|
|  |                     | SPP        | SPA                                  |                  |
| Continuous drain current<br>$T_C = 25\text{ }^\circ\text{C}$<br>$T_C = 100\text{ }^\circ\text{C}$                  | $I_D$               | 4<br>2.5   | 4 <sup>1)</sup><br>2.5 <sup>1)</sup> | A                |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$  | $I_{D\text{ puls}}$ | 12         | 12                                   | A                |
| Avalanche energy, single pulse<br>$I_D=0.8\text{A}$ , $V_{DD}=50\text{V}$  | $E_{AS}$            | 170        | 170                                  | mJ               |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>2)</sup><br>$I_D=4\text{A}$ , $V_{DD}=50\text{V}$ | $E_{AR}$            | 0.1        | 0.1                                  |                  |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$   | $I_{AR}$            | 4          | 4                                    | A                |
| Gate source voltage  | $V_{GS}$            | $\pm 20$   | $\pm 20$                             | V                |
| Gate source voltage AC ( $f > 1\text{Hz}$ )  | $V_{GS}$            | $\pm 30$   | $\pm 30$                             |                  |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$  | $P_{tot}$           | 63         | 38                                   | W                |
| Operating and storage temperature  | $T_j, T_{stg}$      | -55...+150 |                                      | $^\circ\text{C}$ |

**Maximum Ratings**

| Parameter   | Symbol  | Value | Unit |
|---|---------|-------|------|
| Drain Source voltage slope<br>$V_{DS} = 640 \text{ V}$ , $I_D = 4 \text{ A}$ , $T_j = 125 \text{ }^\circ\text{C}$ | $dv/dt$ | 50    | V/ns |

**Thermal Characteristics**

| Parameter   | Symbol                | Values |      |      | Unit             |
|---|-----------------------|--------|------|------|------------------|
|   |                       | min.   | typ. | max. |                  |
| Thermal resistance, junction - case   | $R_{thJC}$            | -      | -    | 2    | K/W              |
| Thermal resistance, junction - case, FullPAK  | $R_{thJC \text{ FP}}$ | -      | -    | 4    |                  |
| Thermal resistance, junction - ambient, leaded  | $R_{thJA}$            | -      | -    | 62   |                  |
| Thermal resistance, junction - ambient, FullPAK   | $R_{thJA \text{ FP}}$ | -      | -    | 80   |                  |
| Soldering temperature, wavesoldering<br>1.6 mm (0.063 in.) from case for 10s <sup>3</sup> ) | $T_{sold}$            | -      | -    | 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           | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}$ , $I_D=0.25\text{mA}$   | 800    | -    | -    | V             |
| Drain-Source avalanche breakdown voltage | $V_{(BR)DS}$  | $V_{GS}=0\text{V}$ , $I_D=4\text{A}$   | -      | 870  | -    |               |
| Gate threshold voltage                   | $V_{GS(th)}$  | $I_D=240\mu\text{A}$ , $V_{GS}=V_{DS}$   | 2.1    | 3    | 3.9  |               |
| Zero gate voltage drain current          | $I_{DSS}$     | $V_{DS}=800\text{V}$ , $V_{GS}=0\text{V}$ ,<br>$T_j=25^\circ\text{C}$<br>$T_j=150^\circ\text{C}$ | -      | 0.5  | 10   | $\mu\text{A}$ |
|  |               |  | -      | -    | 100  |               |
| Gate-source leakage current              | $I_{GSS}$     | $V_{GS}=20\text{V}$ , $V_{DS}=0\text{V}$   | -      | -    | 100  | nA            |
| Drain-source on-state resistance         | $R_{DS(on)}$  | $V_{GS}=10\text{V}$ , $I_D=2.5\text{A}$<br>$T_j=25^\circ\text{C}$<br>$T_j=150^\circ\text{C}$     | -      | 1.1  | 1.3  | $\Omega$      |
|  |               |  | -      | 3    | -    |               |
| Gate input resistance                    | $R_G$         | $f=1\text{MHz}$ , open drain   | -      | 0.7  | -    |               |

**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>$I_D = 2.5A$ | -      | 3    | -    | S    |
| Input capacitance   | $C_{iss}$    | $V_{GS} = 0V$ , $V_{DS} = 25V$ ,                                | -      | 570  | -    | pF   |
| Output capacitance  | $C_{oss}$    | $f = 1MHz$  | -      | 240  | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |   | -      | 12   | -    |      |
| Effective output capacitance, <sup>4)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0V$ ,<br>$V_{DS} = 0V$ to 480V                        | -      | 15.6 | -    |      |
| Effective output capacitance, <sup>5)</sup><br>time related   | $C_{o(tr)}$  |   | -      | 33.7 | -    |      |
| Turn-on delay time  | $t_{d(on)}$  | $V_{DD} = 400V$ , $V_{GS} = 0/10V$ ,                            | -      | 25   | -    | ns   |
| Rise time   | $t_r$        | $I_D = 4A$ ,  | -      | 15   | -    |      |
| Turn-off delay time   | $t_{d(off)}$ | $R_G = 22\Omega$  | -      | 65   | 75   |      |
| Fall time   | $t_f$        |   | -      | 12   | 16   |      |

**Gate Charge Characteristics**

|                       |                 |   |   |     |    |    |
|-----------------------|-----------------|---|---|-----|----|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 640V$ , $I_D = 4A$                          | - | 2.4 | -  | nC |
| Gate to drain charge  | $Q_{gd}$        |   | - | 11  | -  |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 640V$ , $I_D = 4A$ ,<br>$V_{GS} = 0$ to 10V | - | 20  | 26 |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 640V$ , $I_D = 4A$                          | - | 6   | -  | 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>Soldering temperature for TO-263: 220°C, reflow

<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%  $V_{DSS}$ .

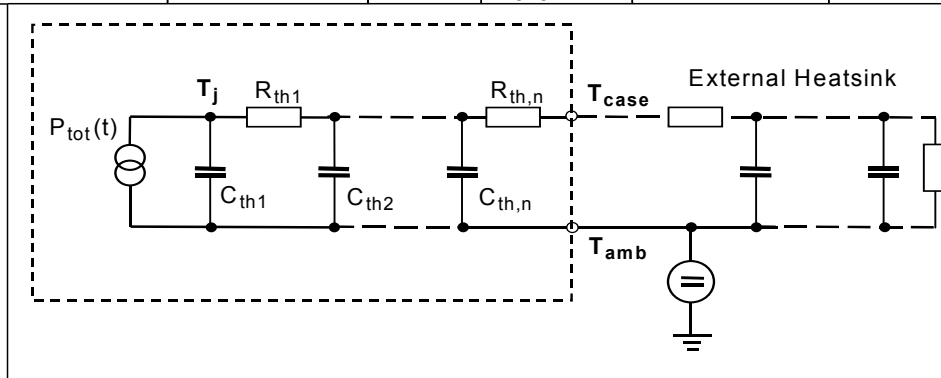
<sup>5</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

**Electrical Characteristics**

| Parameter                                     | Symbol       | Conditions                        | Values |      |      | Unit                   |
|---|--------------|-----------------------------------|--------|------|------|------------------------|
|   |              |                                   | min.   | typ. | max. |                        |
| Inverse diode continuous forward current      | $I_S$        | $T_C=25^\circ\text{C}$            | -      | -    | 4    | A                      |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                   | -      | -    | 12   |                        |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0\text{V}, I_F=I_S$       | -      | 1    | 1.2  | V                      |
| Reverse recovery time                         | $t_{rr}$     | $V_R=640\text{V}, I_F=I_S,$       | -      | 520  | -    | ns                     |
| Reverse recovery charge                       | $Q_{rr}$     | $di_F/dt=100\text{A}/\mu\text{s}$ | -      | 4    | -    | $\mu\text{C}$          |
| Peak reverse recovery current                 | $I_{rrm}$    |                                   | -      | 12   | -    | A                      |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ | $T_j=25^\circ\text{C}$            | -      | 300  | -    | $\text{A}/\mu\text{s}$ |

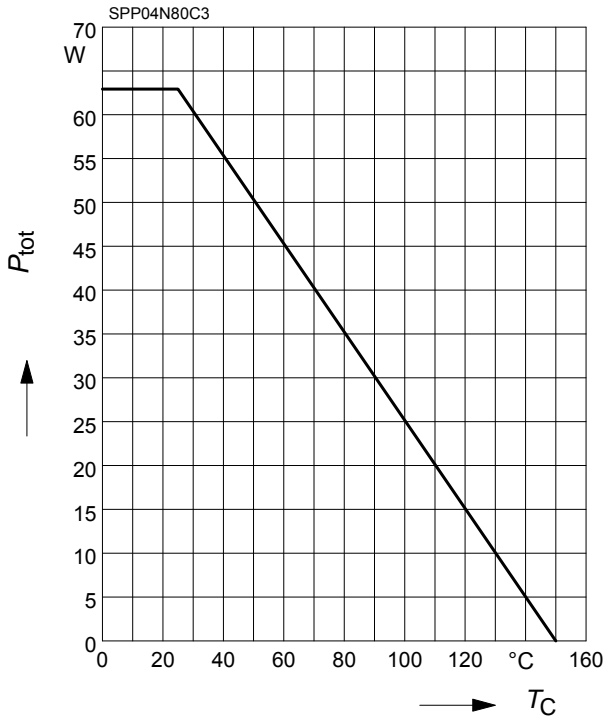
**Typical Transient Thermal Characteristics**

| Symbol    | Value |       | Unit | Symbol    | Value      |            | Unit |
|-----------|-------|-------|------|-----------|------------|------------|------|
|           | SPP   | SPA   |      |           | SPP        | SPA        |      |
| $R_{th1}$ | 0.033 | 0.033 | K/W  | $C_{th1}$ | 0.00008691 | 0.00008691 | Ws/K |
| $R_{th2}$ | 0.063 | 0.063 |      | $C_{th2}$ | 0.0003336  | 0.0003336  |      |
| $R_{th3}$ | 0.113 | 0.113 |      | $C_{th3}$ | 0.0004755  | 0.0004755  |      |
| $R_{th4}$ | 0.432 | 0.237 |      | $C_{th4}$ | 0.001405   | 0.001405   |      |
| $R_{th5}$ | 0.423 | 0.515 |      | $C_{th5}$ | 0.003503   | 0.006369   |      |
| $R_{th6}$ | 0.14  | 2.517 |      | $C_{th6}$ | 0.036      | 0.412      |      |



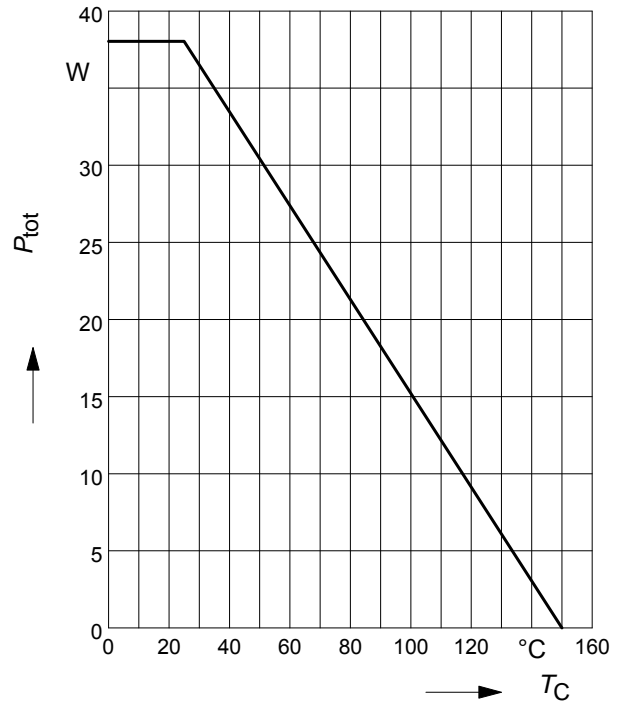
**1 Power dissipation**

$P_{tot} = f(T_C)$



**2 Power dissipation FullPAK**

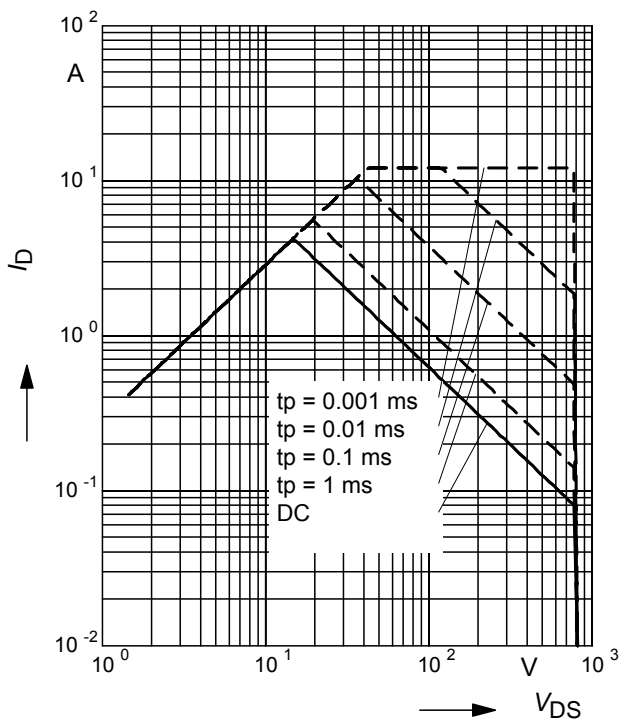
$P_{tot} = f(T_C)$



**3 Safe operating area**

$I_D = f(V_{DS})$

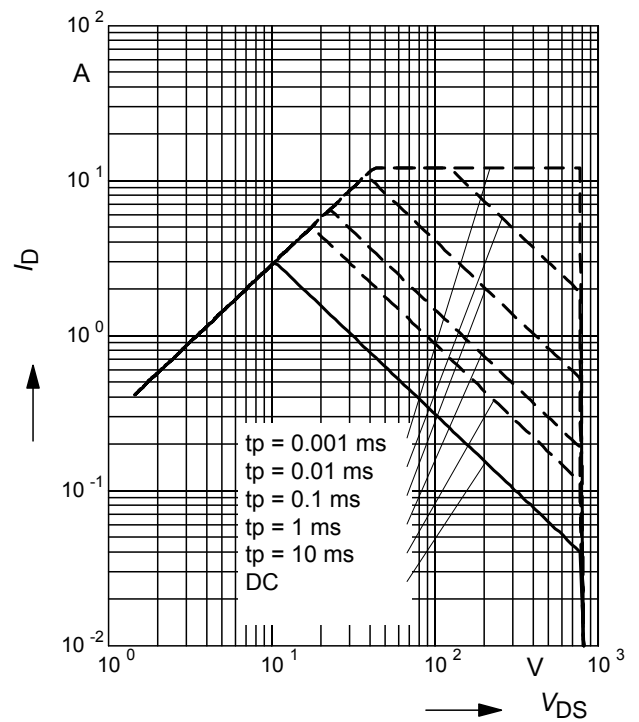
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**4 Safe operating area FullPAK**

$I_D = f(V_{DS})$

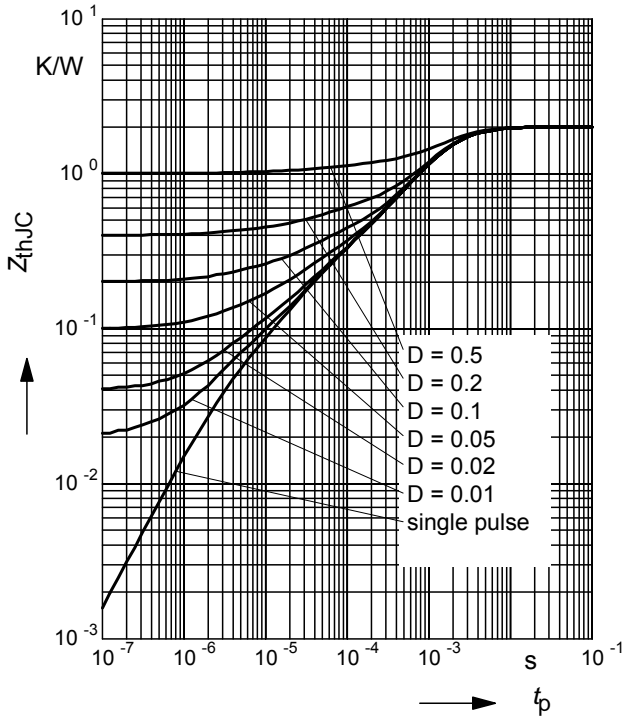
parameter:  $D = 0$  ,  $T_C = 25^\circ\text{C}$



**5 Transient thermal impedance**

$Z_{thJC} = f(t_p)$

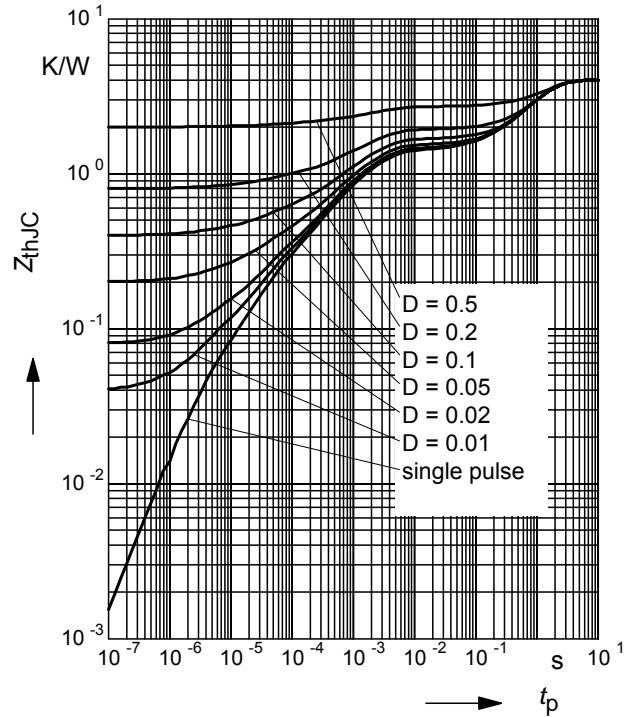
parameter:  $D = t_p/T$



**6 Transient thermal impedance FullPAK**

$Z_{thJC} = f(t_p)$

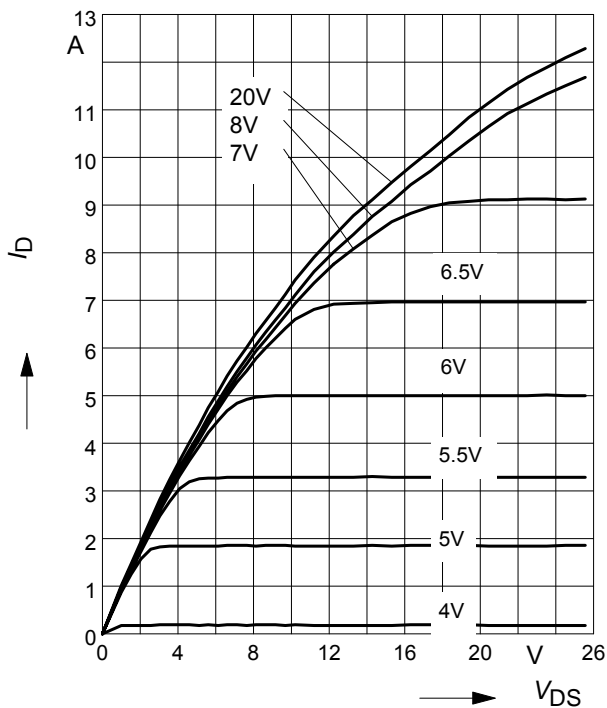
parameter:  $D = t_p/t$



**7 Typ. output characteristic**

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

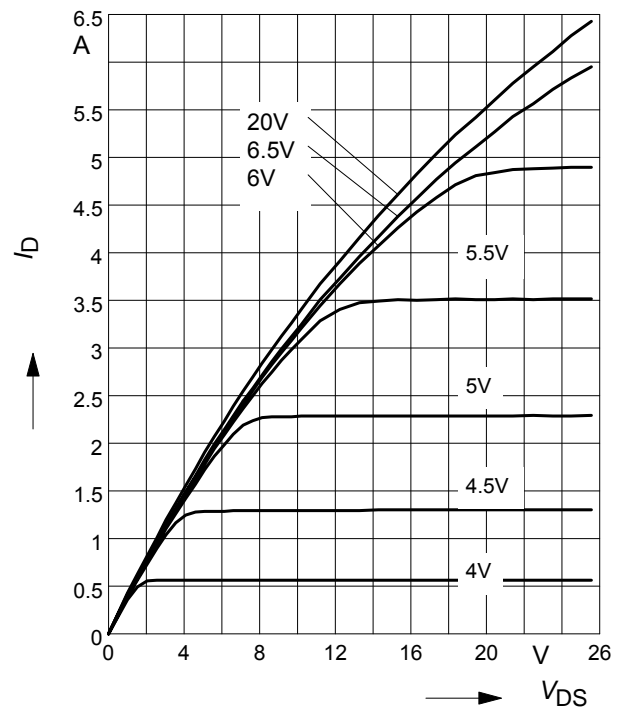
parameter:  $t_p = 10 \mu s, V_{GS}$



**8 Typ. output characteristic**

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

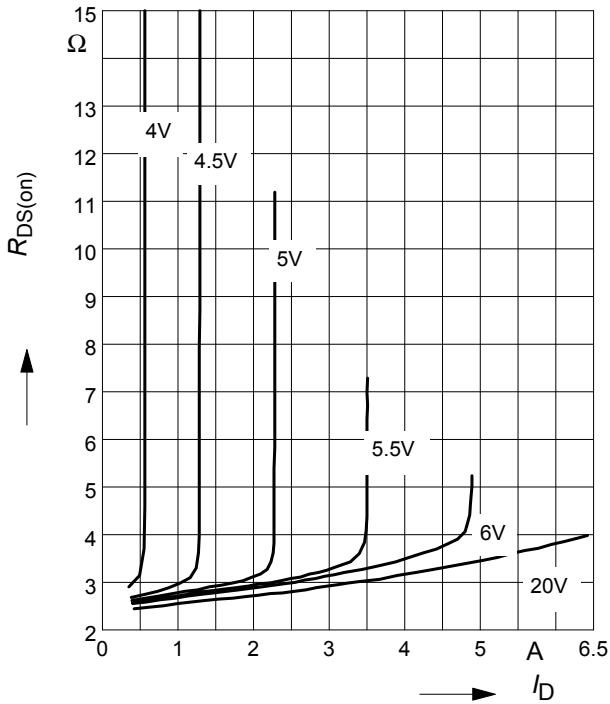
parameter:  $t_p = 10 \mu s, V_{GS}$



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

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

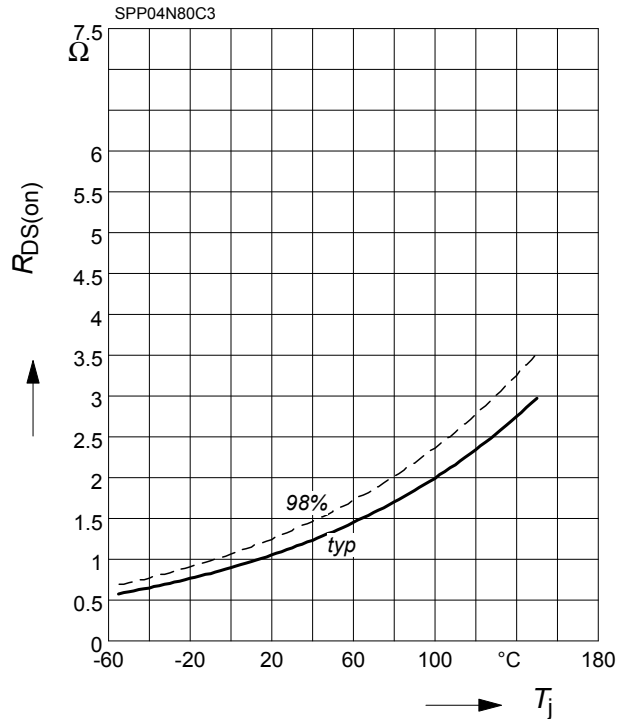
parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$



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

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

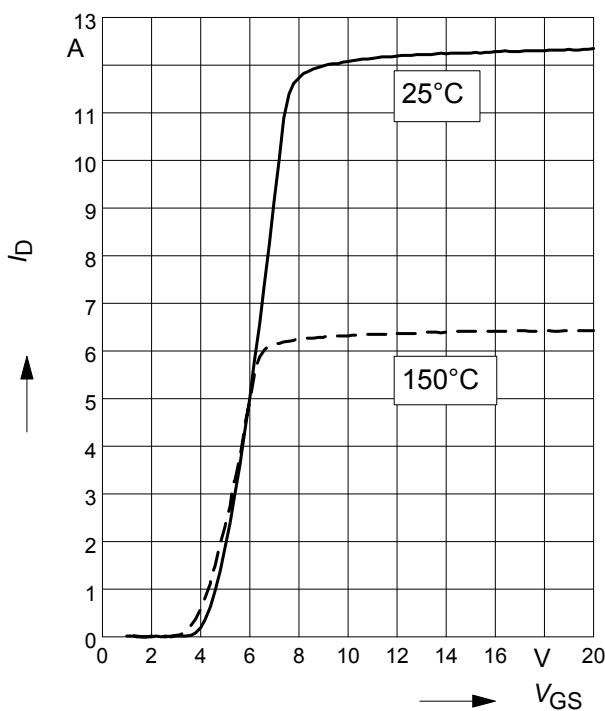
parameter:  $I_D = 2.5\text{ A}$ ,  $V_{GS} = 10\text{ V}$



**11 Typ. transfer characteristics**

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

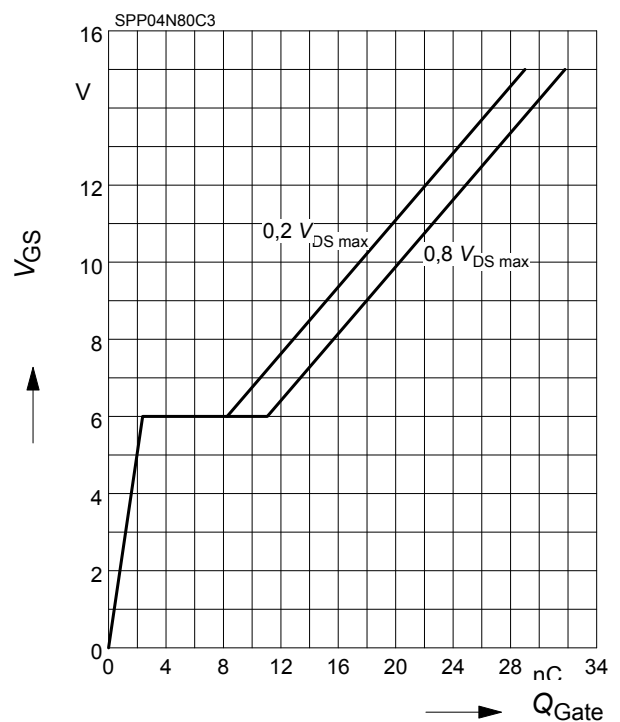
parameter:  $t_p = 10\ \mu\text{s}$



**12 Typ. gate charge**

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

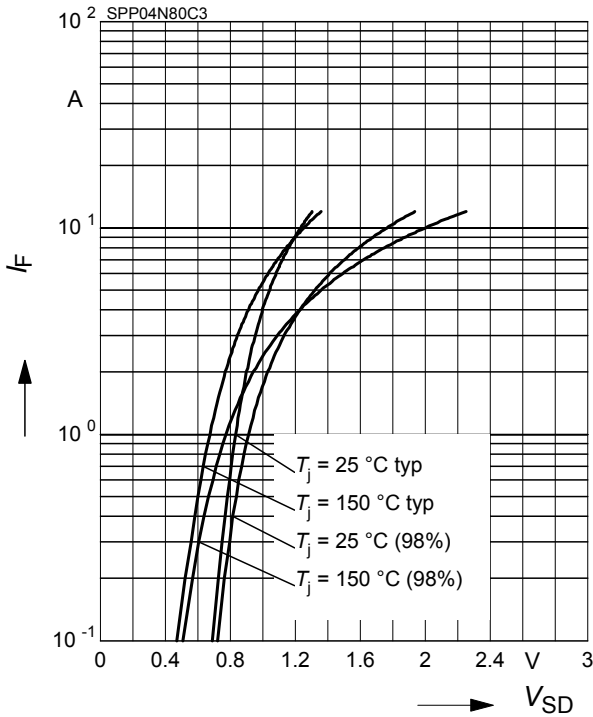
parameter:  $I_D = 4\text{ A pulsed}$



**13 Forward characteristics of body diode**

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

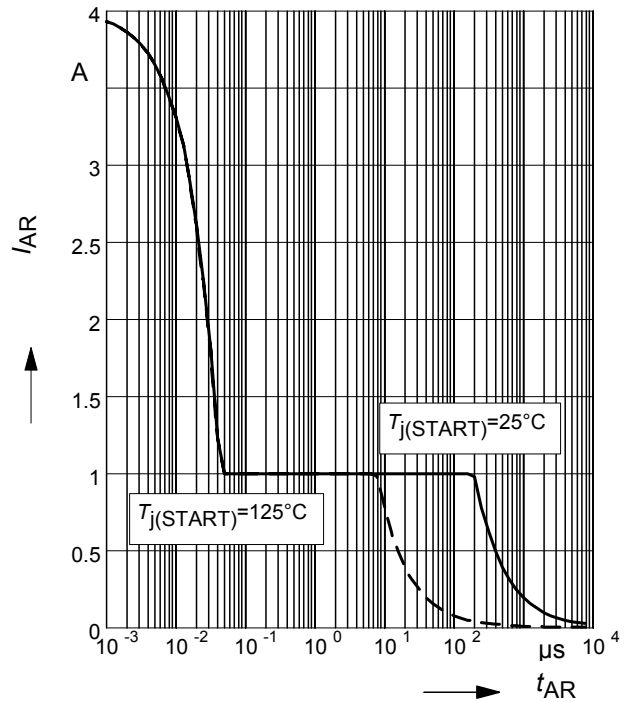
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**14 Avalanche SOA**

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

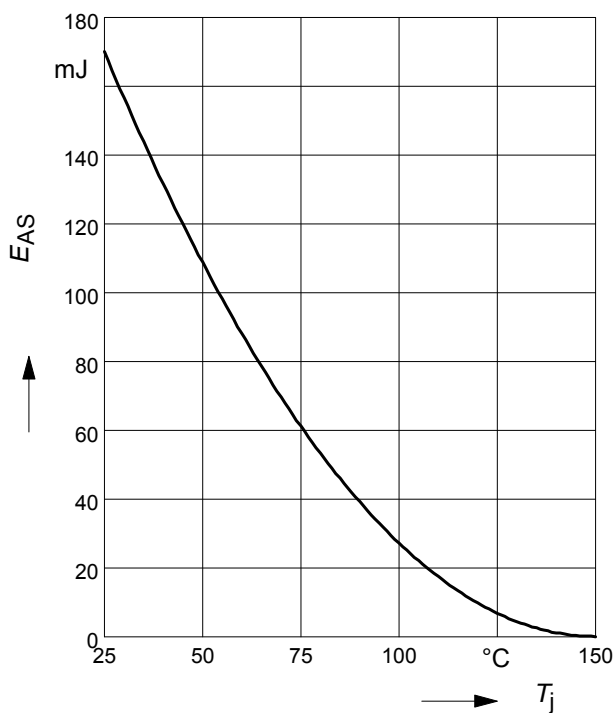
par.:  $T_j \leq 150 \text{ °C}$



**15 Avalanche energy**

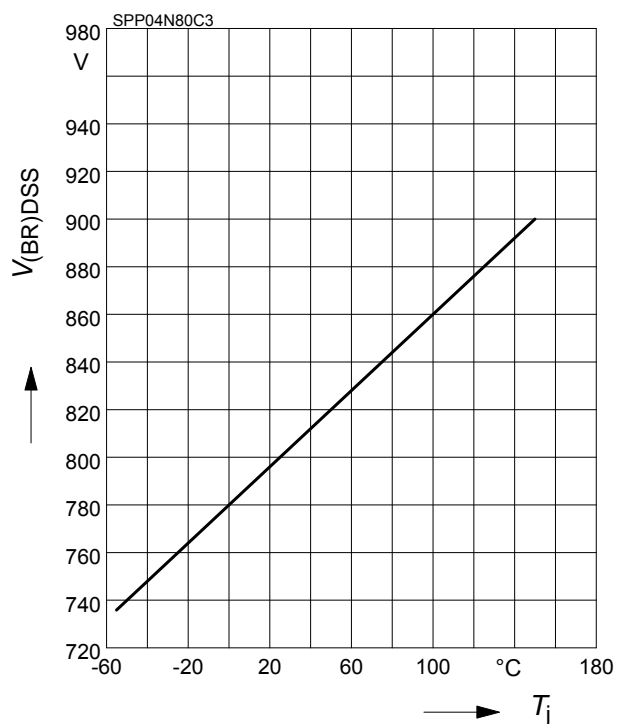
$$E_{AS} = f(T_j)$$

par.:  $I_D = 0.8 \text{ A}$ ,  $V_{DD} = 50 \text{ V}$



**16 Drain-source breakdown voltage**

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

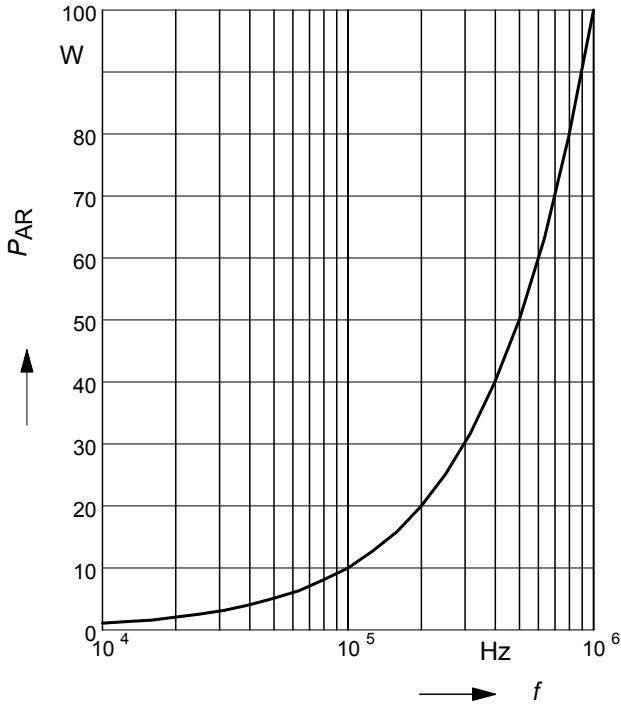




**17 Avalanche power losses**

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

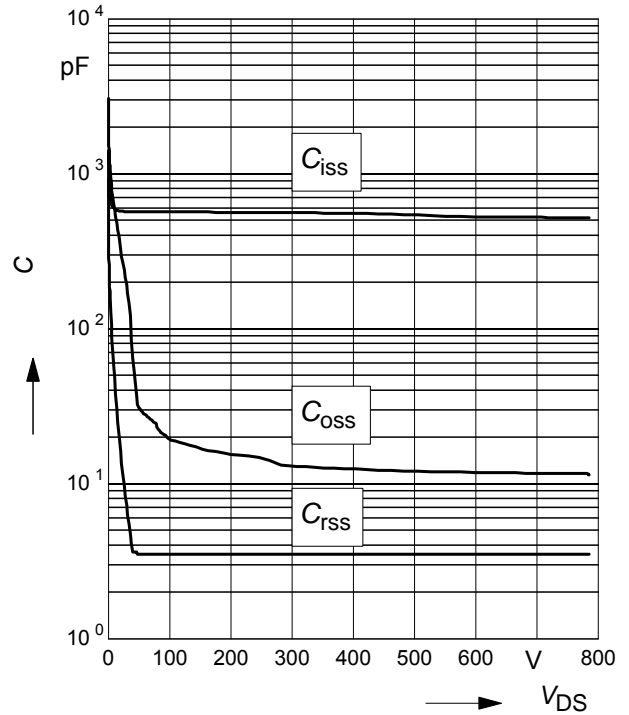
parameter:  $E_{AR}=0.1\text{mJ}$



**18 Typ. capacitances**

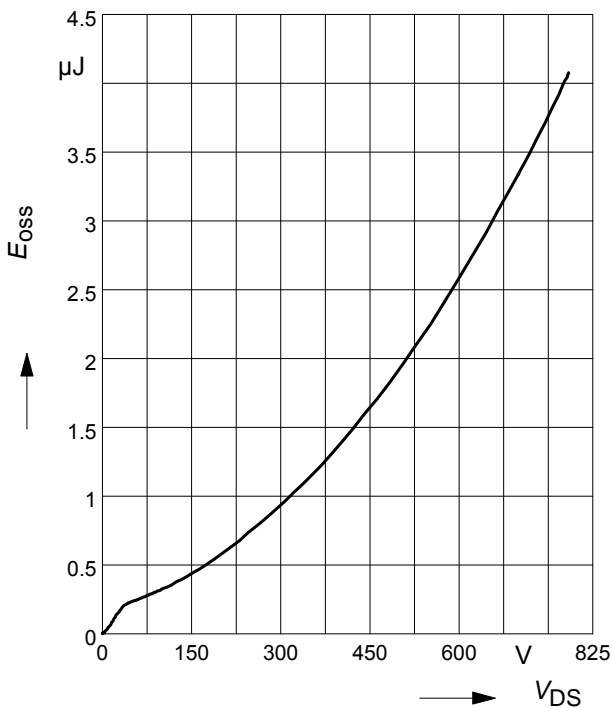
$$C = f(V_{DS})$$

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



**19 Typ. C<sub>oss</sub> stored energy**

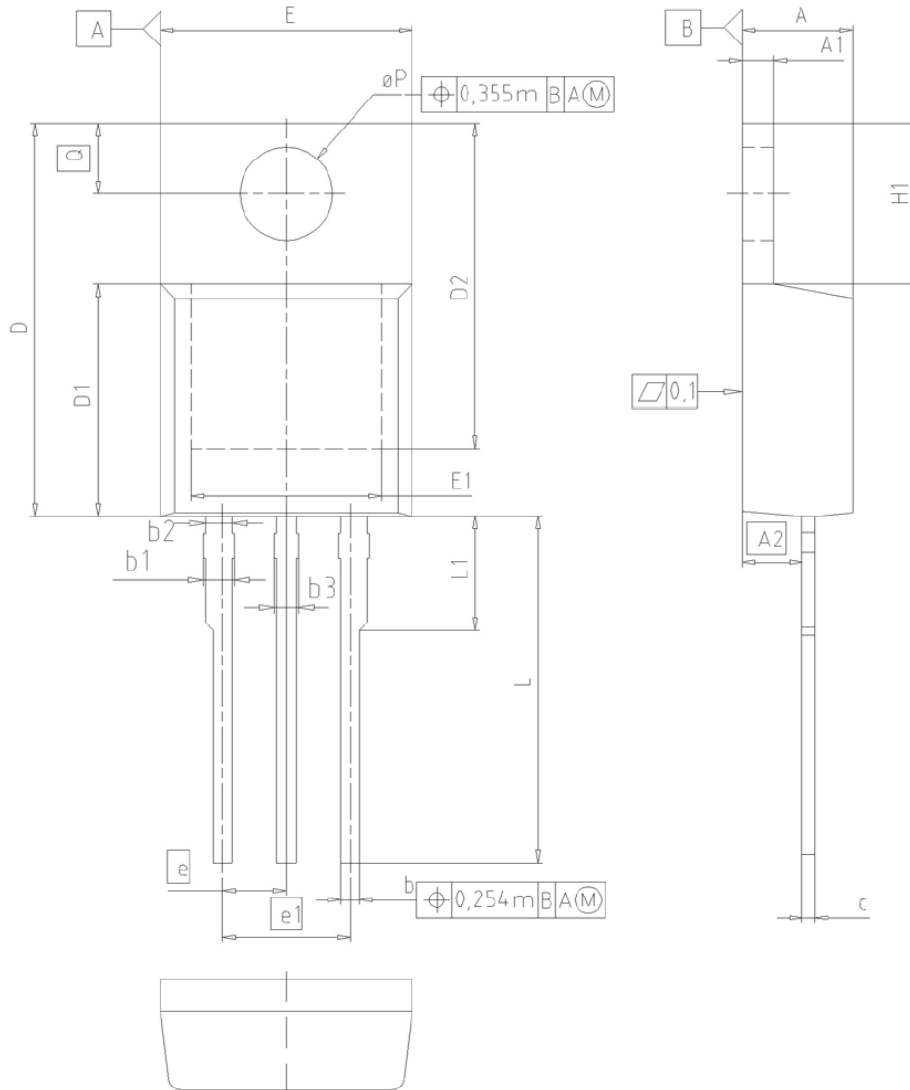
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics



PG-TO220-3-1, 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 |
| $\phi P$ | 3.60        | 3.89  | 0.142  | 0.153 |
| Q        | 2.60        | 3.00  | 0.102  | 0.118 |

**DOCUMENT NO.**  
Z8B00003318

**SCALE**  
0 2.5 5mm

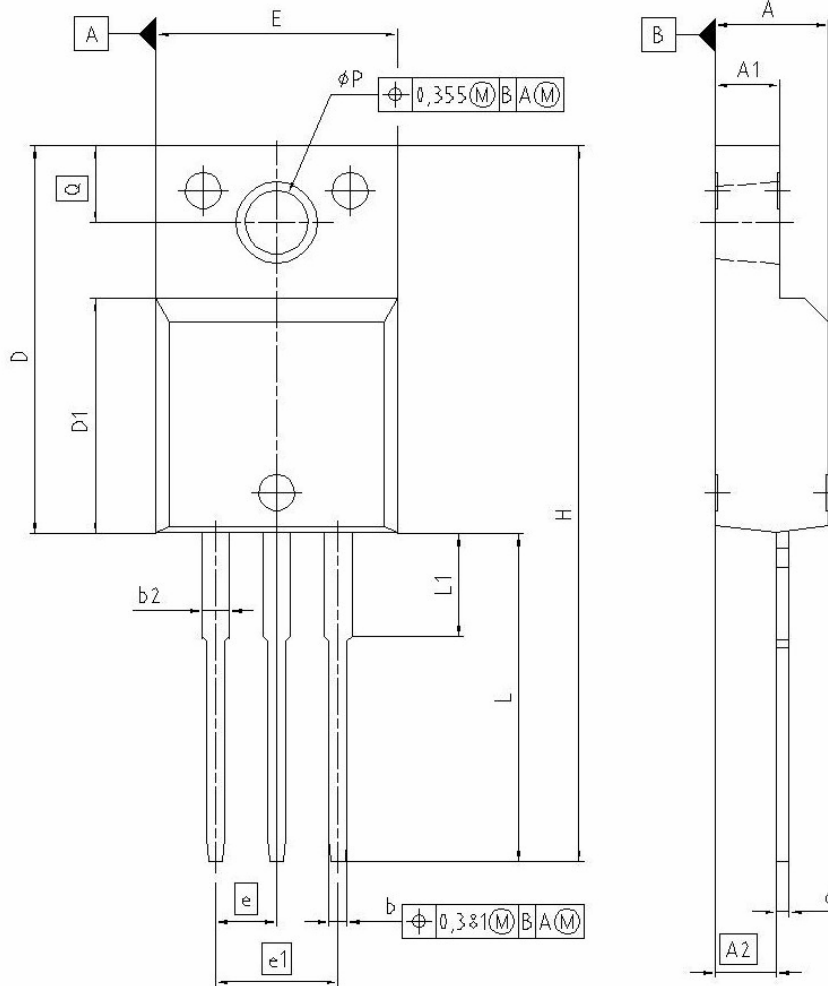
**EUROPEAN PROJECTION**



**ISSUE DATE**  
23-08-2007

**REVISION**  
05

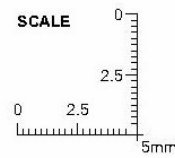
PG-TO220-3-31 (FullPAK)



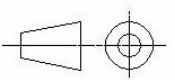
| DIM   | MILLIMETERS |        | INCHES |       |
|-------|-------------|--------|--------|-------|
|       | MIN         | MAX    | MIN    | MAX   |
| A     | 4.572       | 4.826  | 0.180  | 0.190 |
| A1    | 2.573       | 2.827  | 0.101  | 0.111 |
| A2    | 2.514       | 2.616  | 0.099  | 0.103 |
| b     | 0.649       | 0.776  | 0.025  | 0.030 |
| b2    | 1.143       | 1.509  | 0.045  | 0.059 |
| c     | 0.449       | 0.627  | 0.017  | 0.027 |
| D     | 15.863      | 16.117 | 0.624  | 0.634 |
| D1    | 9.554       | 9.808  | 0.376  | 0.386 |
| E     | 10.373      | 10.627 | 0.408  | 0.418 |
| e     | 2.540       |        | 0.100  |       |
| e1    | 5.080       |        | 0.200  |       |
| N     | 3           |        | 3      |       |
| H     | 29.463      | 29.717 | 1.160  | 1.170 |
| L     | 13.473      | 13.727 | 0.530  | 0.540 |
| L1    | 3.175       | 3.429  | 0.125  | 0.135 |
| phi P | 2.949       | 3.025  | 0.119  | 0.116 |
| Q     | 3.149       | 3.251  | 0.124  | 0.128 |

**REFERENCE**  
J...

**SCALE**



**EUROPEAN PROJECTION**



**ISSUE DATE**  
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TO220\_2

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