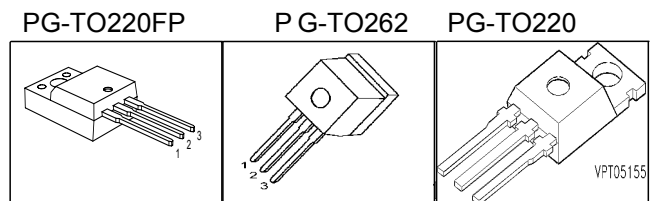


Cool MOS™ Power Transistor

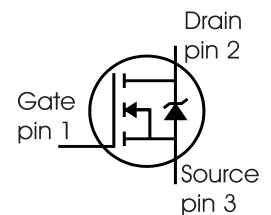
Feature

- New revolutionary high voltage technology
 - Worldwide best $R_{DS(on)}$ in TO 220
 - Ultra low gate charge
 - Periodic avalanche rated
 - Extreme dv/dt rated
 - Ultra low effective capacitances
 - Improved transconductance
-
- Pb-free lead plating; RoHS compliant
 - Qualified according to JEDEC⁰⁾ for target applications

| | | |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 560 | V |
| $R_{DS(on)}$ | 0.19 | Ω |
| I_D | 21 | A |



| Type | Package | Ordering Code | Marking |
|------------|------------|---------------|---------|
| SPP21N50C3 | PG-TO220 | Q67040-S4565 | 21N50C3 |
| SPI21N50C3 | PG-TO262 | Q67040-S4564 | 21N50C3 |
| SPA21N50C3 | PG-TO220FP | SP000216364 | 21N50C3 |



Maximum Ratings

| Parameter | Symbol | Value | | Unit |
|---|----------------|------------|--|------------------|
| | | SPP_I | SPA | |
| Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$ | I_D | 21 13.1 | 21 ¹⁾ 13.1 ¹⁾ | A |
| Pulsed drain current, t_p limited by T_{jmax} | I_D puls | 63 | 63 | A |
| Avalanche energy, single pulse $I_D=10\text{A}$, $V_{DD}=50\text{V}$ | E_{AS} | 690 | 690 | mJ |
| Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=21\text{A}$, $V_{DD}=50\text{V}$ | E_{AR} | 1 | 1 | |
| Avalanche current, repetitive t_{AR} limited by T_{jmax} | I_{AR} | 21 | 21 | A |
| Gate source voltage | V_{GS} | ± 20 | ± 20 | V |
| Gate source voltage AC ($f > 1\text{Hz}$) | V_{GS} | ± 30 | ± 30 | |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$ | P_{tot} | 208 | 34.5 | W |
| Operating and storage temperature | T_j, T_{stg} | -55...+150 | | $^\circ\text{C}$ |
| Reverse diode dv/dt ⁷⁾ | dv/dt | 15 | | V/ns |

Maximum Ratings

| Parameter | Symbol | Value | Unit |
|--|---------|-------|------|
| Drain Source voltage slope $V_{DS} = 400 \text{ V}, I_D = 21 \text{ A}, T_j = 125 \text{ }^\circ\text{C}$ | dv/dt | 50 | V/ns |

Thermal Characteristics

| Parameter | Symbol | Values | | | Unit |
|---|-----------------------|--------|------|------|------|
| | | min. | typ. | max. | |
| Thermal resistance, junction - case | R_{thJC} | - | - | 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: @ min. footprint @ 6 cm ² cooling area ³⁾ | R_{thJA} | - | - | 62 | |
| | | - | 35 | - | |
| Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s ⁴⁾ | T_{sold} | - | - | 260 | °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 | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}, I_D=0.25\text{mA}$ | 500 | - | - | V |
| Drain-Source avalanche breakdown voltage | $V_{(BR)DS}$ | $V_{GS}=0\text{V}, I_D=21\text{A}$ | - | 600 | - | |
| 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} | $V_{DS}=500\text{V}, V_{GS}=0\text{V},$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$ | - | 0.1 | 1 | μA |
| | | | - | - | 100 | |
| Gate-source leakage current | I_{GSS} | $V_{GS}=20\text{V}, V_{DS}=0\text{V}$ | - | - | 100 | nA |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}=10\text{V}, I_D=13.1\text{A}$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$ | - | 0.16 | 0.19 | Ω |
| | | | - | 0.54 | - | |
| Gate input resistance | R_G | $f=1\text{MHz}, \text{open drain}$ | - | 0.53 | - | |

Electrical Characteristics

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|--|--------|------|------|------|
| | | | min. | typ. | max. | |
| Transconductance | g_{fs} | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 13.1A$ | - | 18 | - | S |
| Input capacitance | C_{iss} | $V_{GS} = 0V$, $V_{DS} = 25V$, | - | 2400 | - | pF |
| Output capacitance | C_{oss} | $f = 1MHz$ | - | 1200 | - | |
| Reverse transfer capacitance | C_{rss} | | - | 30 | - | |
| Effective output capacitance, ⁵⁾ energy related | $C_{o(er)}$ | $V_{GS} = 0V$, $V_{DS} = 400V$ | - | 87 | - | |
| Effective output capacitance, ⁶⁾ time related | $C_{o(tr)}$ | | - | 181 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 380V$, $V_{GS} = 0/10V$, | - | 10 | - | ns |
| Rise time | t_r | $I_D = 21A$, | - | 5 | - | |
| Turn-off delay time | $t_{d(off)}$ | $R_G = 3.6\Omega$ | - | 67 | - | |
| Fall time | t_f | | - | 4.5 | - | |

Gate Charge Characteristics

| | | | | | | |
|-----------------------|-----------------|--|---|----|---|----|
| Gate to source charge | Q_{gs} | $V_{DD} = 380V$, $I_D = 21A$ | - | 10 | - | nC |
| Gate to drain charge | Q_{gd} | | - | 50 | - | |
| Gate charge total | Q_g | $V_{DD} = 380V$, $I_D = 21A$, $V_{GS} = 0$ to $10V$ | - | 95 | - | |
| Gate plateau voltage | $V_{(plateau)}$ | $V_{DD} = 380V$, $I_D = 21A$ | - | 5 | - | V |

⁰J-STD20 and JESD22

¹Limited only by maximum temperature

²Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

³Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

⁴Soldering temperature for TO-263: 220°C, reflow

⁵ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁶ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁷ $I_{SD} \leq I_D$, $di/dt \leq 200A/\mu s$, $V_{Dclink} = 400V$, $V_{peak} < V_{BR, DSS}$, $T_j < T_{j,max}$.

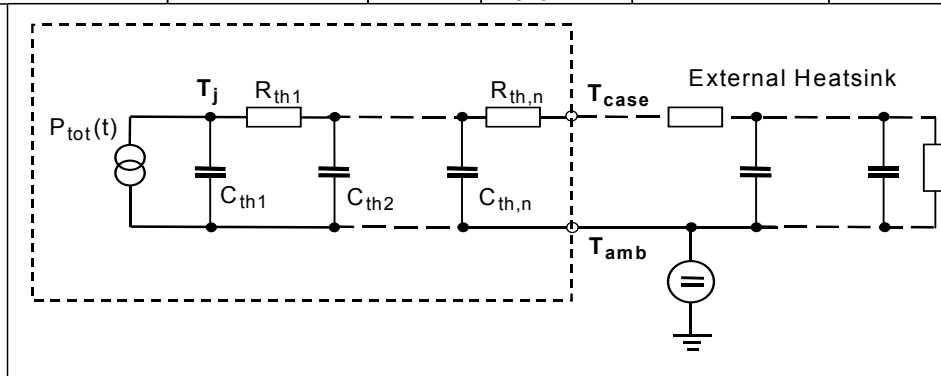
Identical low-side and high-side switch.

Electrical Characteristics

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|-----------------------------------|--------|------|------|------------------------|
| | | | min. | typ. | max. | |
| Inverse diode continuous forward current | I_S | $T_C=25^\circ\text{C}$ | - | - | 21 | A |
| Inverse diode direct current, pulsed | I_{SM} | | - | - | 63 | |
| Inverse diode forward voltage | V_{SD} | $V_{GS}=0\text{V}, I_F=I_S$ | - | 1 | 1.2 | V |
| Reverse recovery time | t_{rr} | $V_R=380\text{V}, I_F=I_S,$ | - | 450 | 720 | ns |
| Reverse recovery charge | Q_{rr} | $di_F/dt=100\text{A}/\mu\text{s}$ | - | 9 | - | μC |
| Peak reverse recovery current | I_{rrm} | | - | 60 | - | A |
| Peak rate of fall of reverse recovery current | di_{rr}/dt | $T_j=25^\circ\text{C}$ | - | 1200 | - | $\text{A}/\mu\text{s}$ |

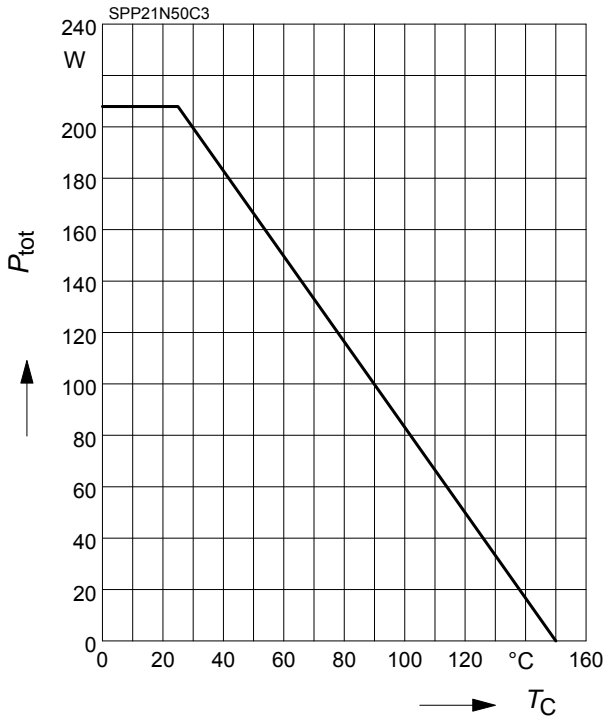
Typical Transient Thermal Characteristics

| 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 | 0.16 | | C_{th4} | 0.005297 | 0.005297 | |
| R_{th5} | 0.136 | 0.319 | | C_{th5} | 0.012 | 0.008659 | |
| R_{th6} | 0.059 | 2.523 | | C_{th6} | 0.091 | 0.412 | |



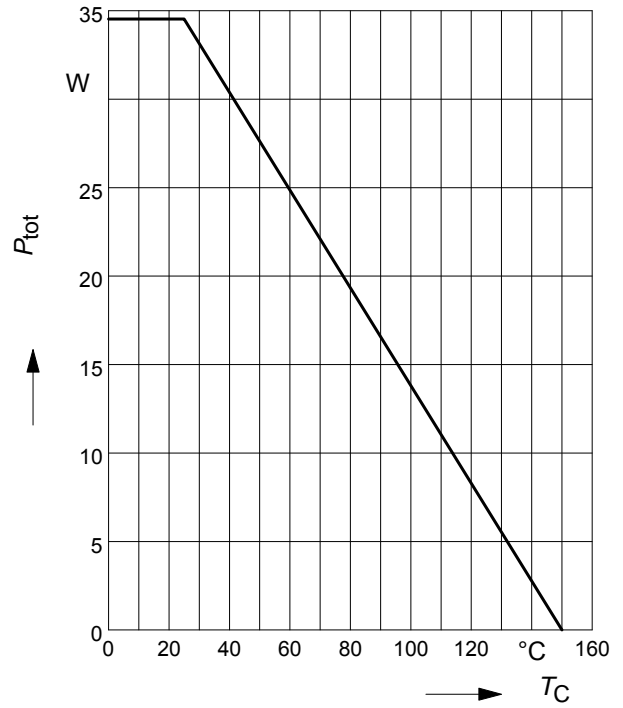
1 Power dissipation

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



2 Power dissipation FullPAK

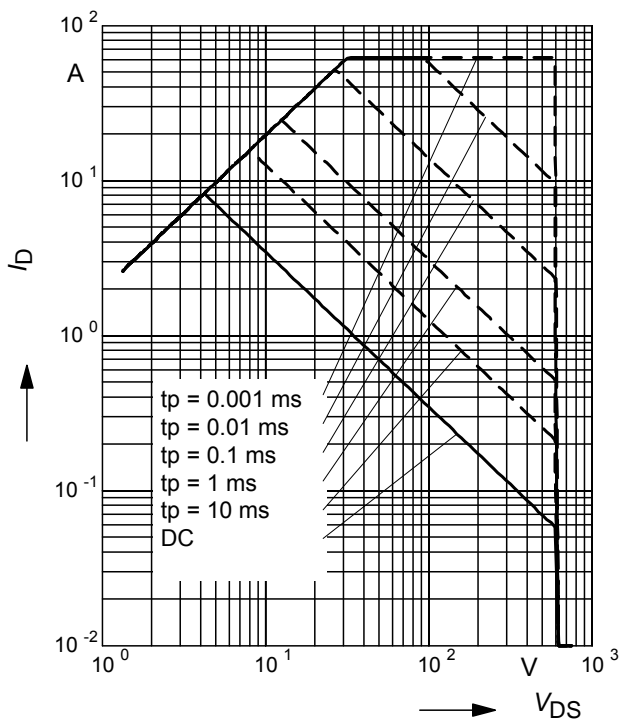
$$P_{tot} = f(T_C)$$



3 Safe operating area

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

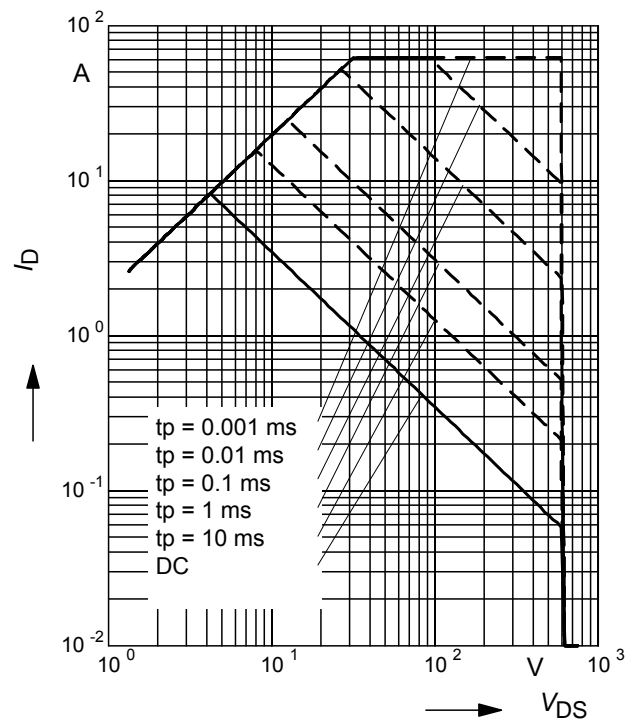
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

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

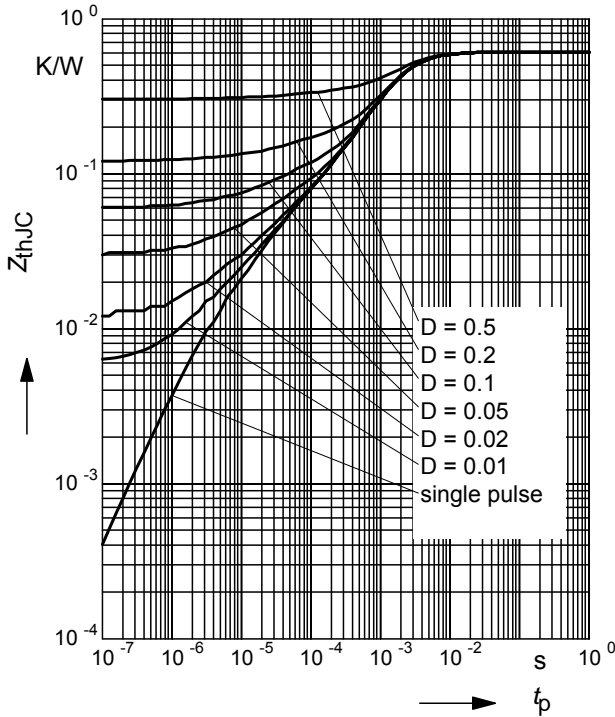
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

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

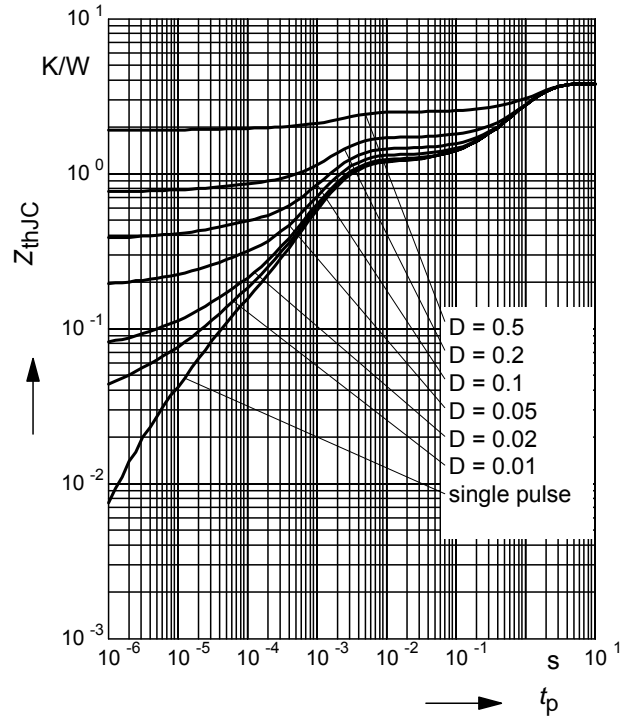
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

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

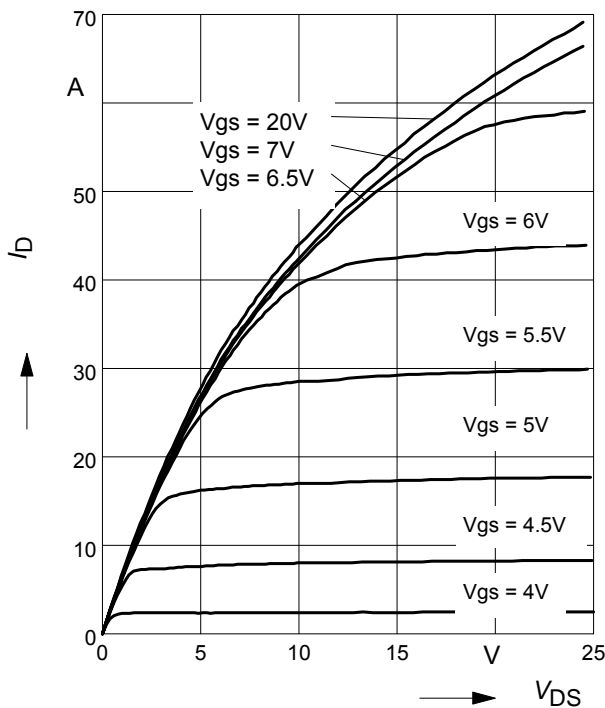
parameter: $D = t_p/t$



7 Typ. output characteristic

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

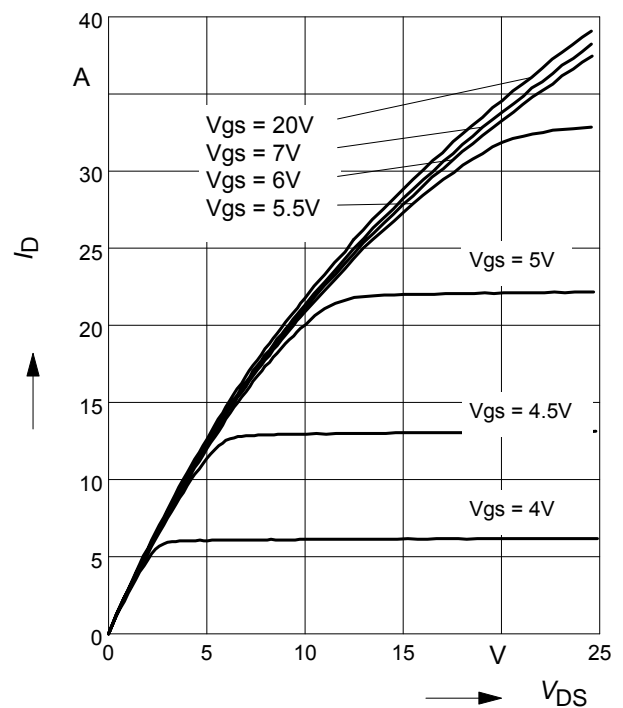
parameter: $t_p = 10 \mu s, V_{GS}$



8 Typ. output characteristic

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

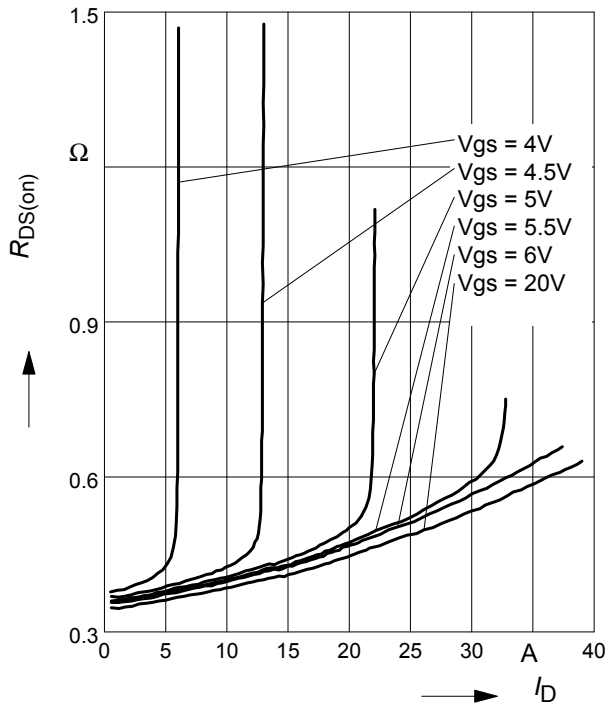
parameter: $t_p = 10 \mu s, V_{GS}$



9 Typ. drain-source on resistance

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

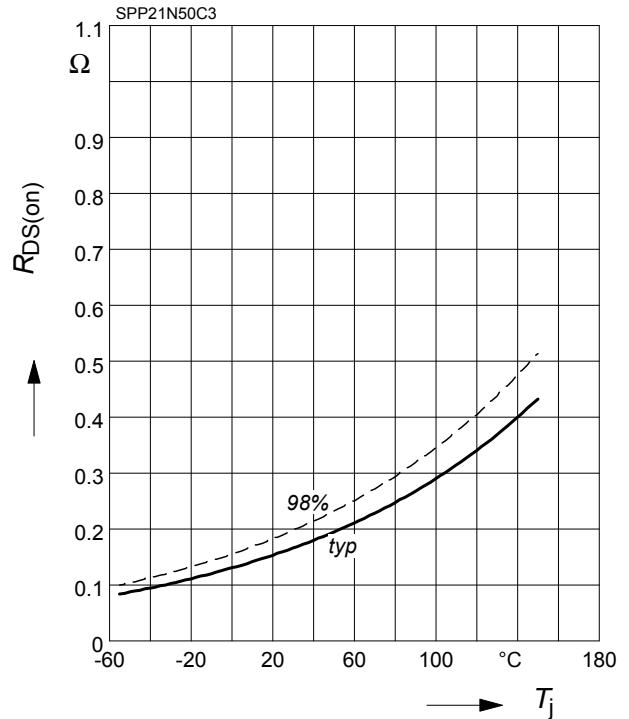
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

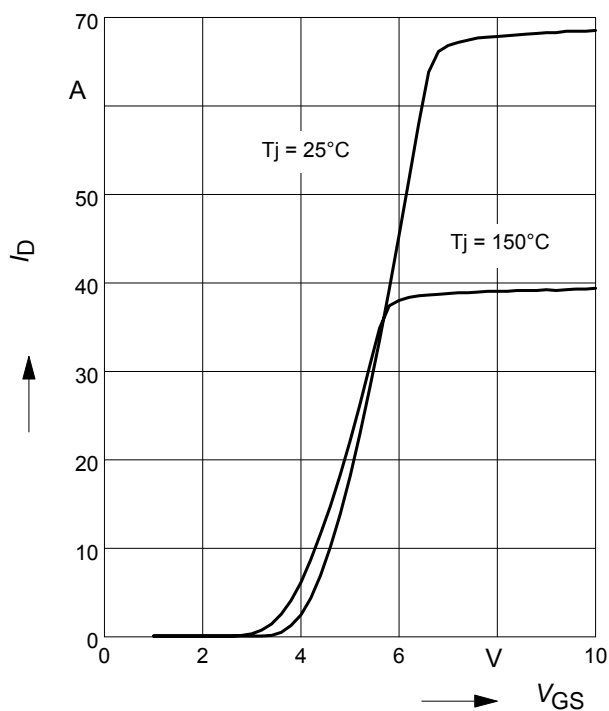
parameter: $I_D = 13.1\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

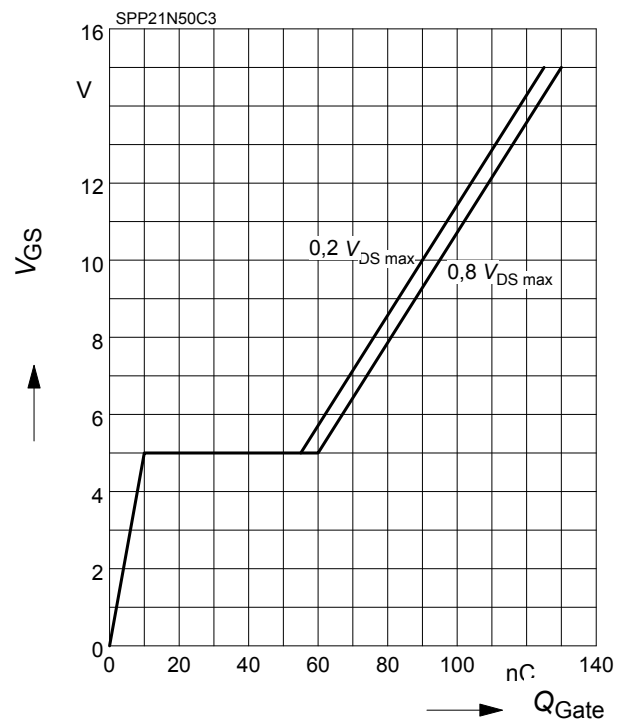
parameter: $t_p = 10\ \mu\text{s}$



12 Typ. gate charge

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

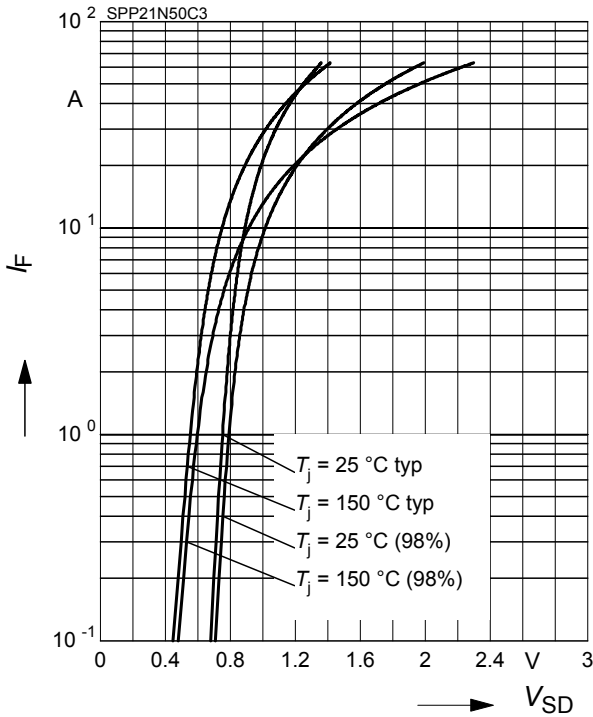
parameter: $I_D = 21\text{ A pulsed}$



13 Forward characteristics of body diode

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

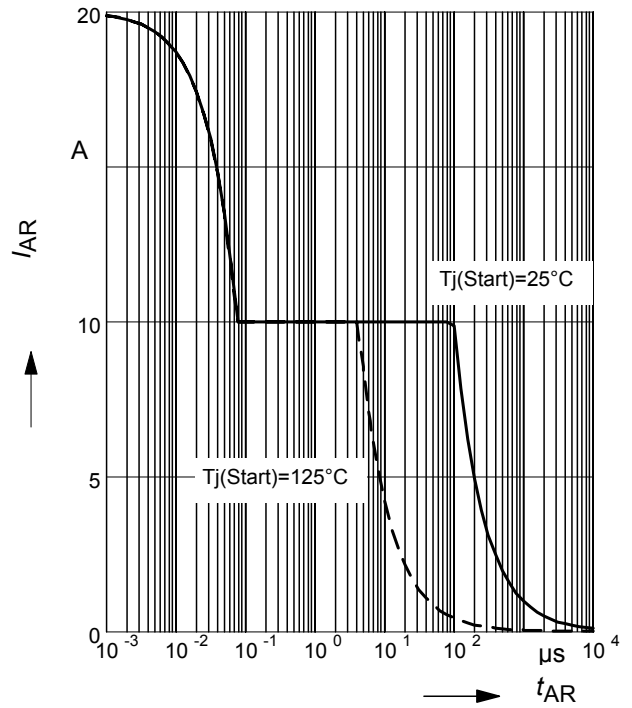
parameter: T_j , $t_p = 10 \mu s$



14 Avalanche SOA

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

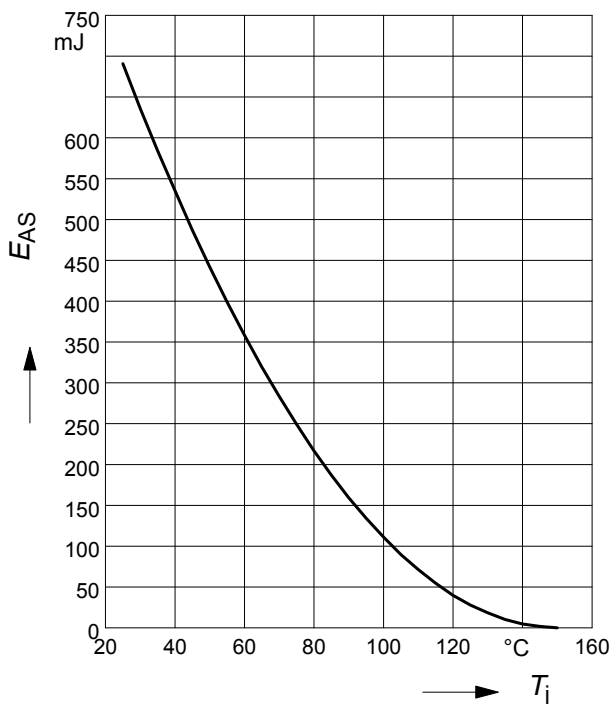
par.: $T_j \leq 150 \text{ °C}$



15 Avalanche energy

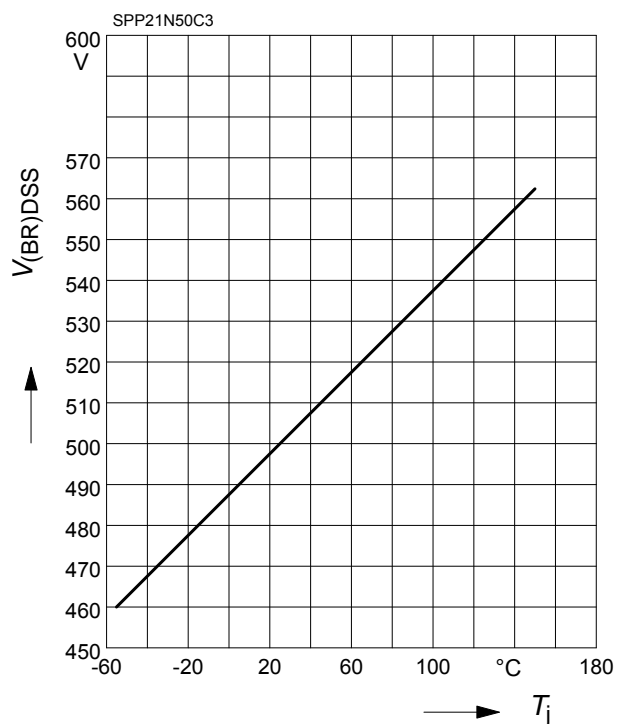
$$E_{AS} = f(T_j)$$

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



16 Drain-source breakdown voltage

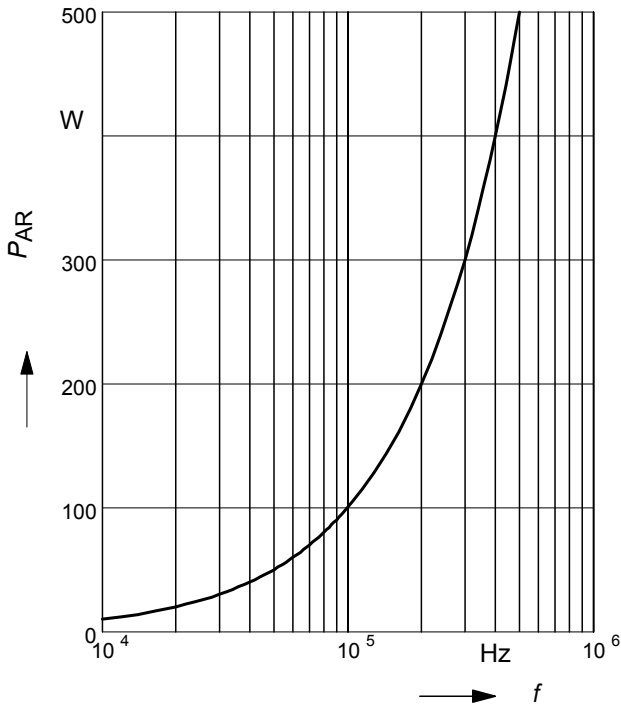
$$V_{(BR)DSS} = f(T_j)$$



17 Avalanche power losses

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

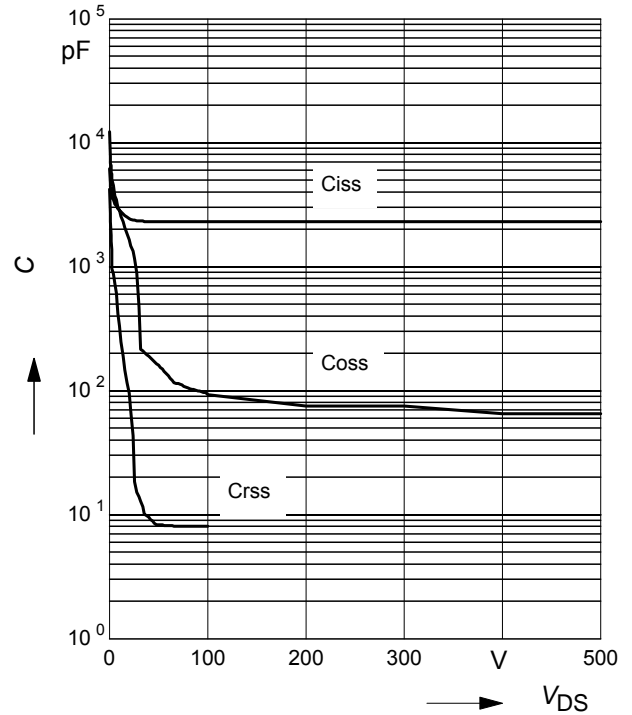
parameter: $E_{AR}=1\text{mJ}$



18 Typ. capacitances

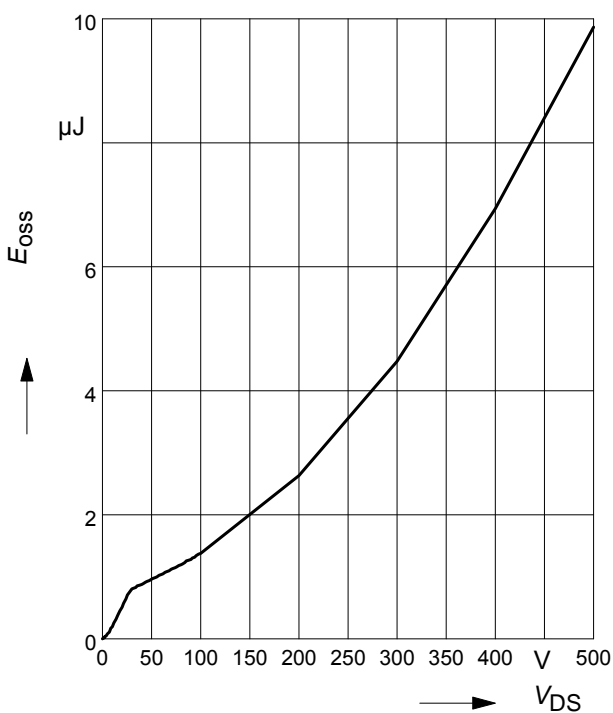
$$C = f(V_{DS})$$

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



19 Typ. C_{OSS} stored energy

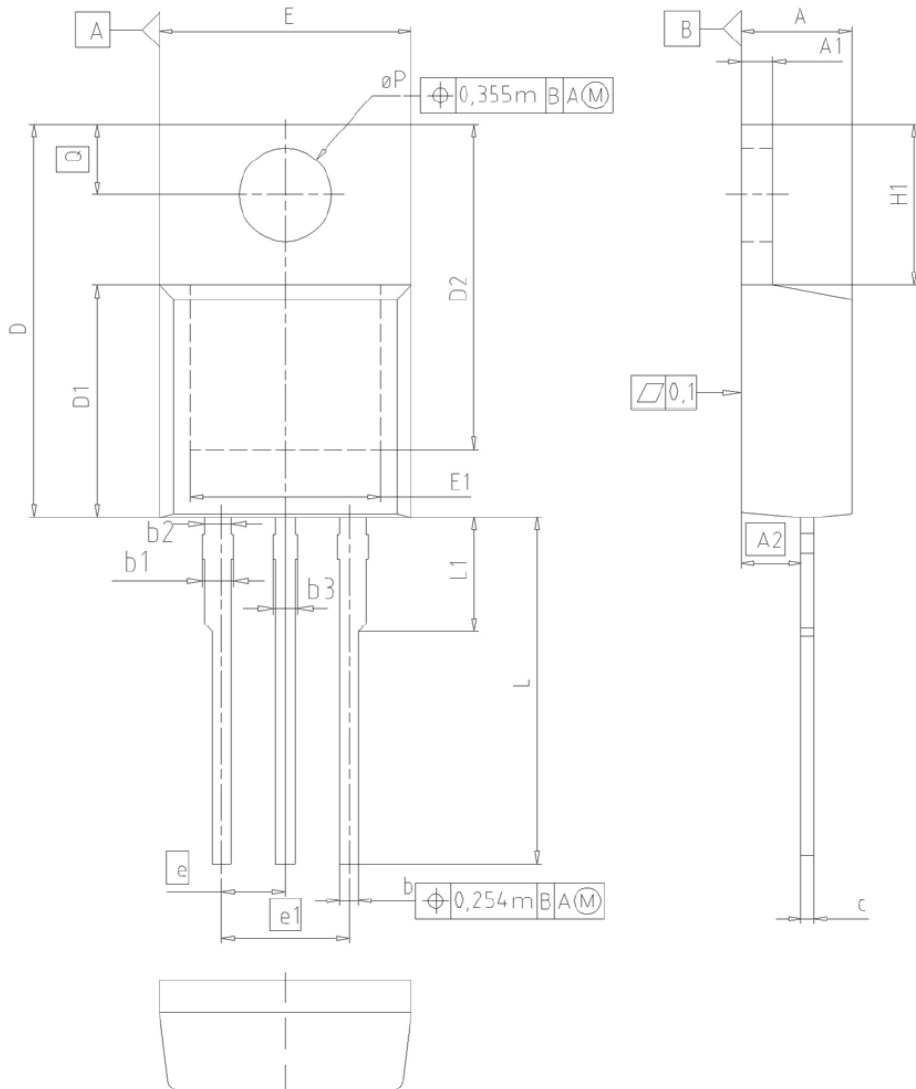
$$E_{OSS}=f(V_{DS})$$



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

DOCUMENT NO.
Z8B00003318

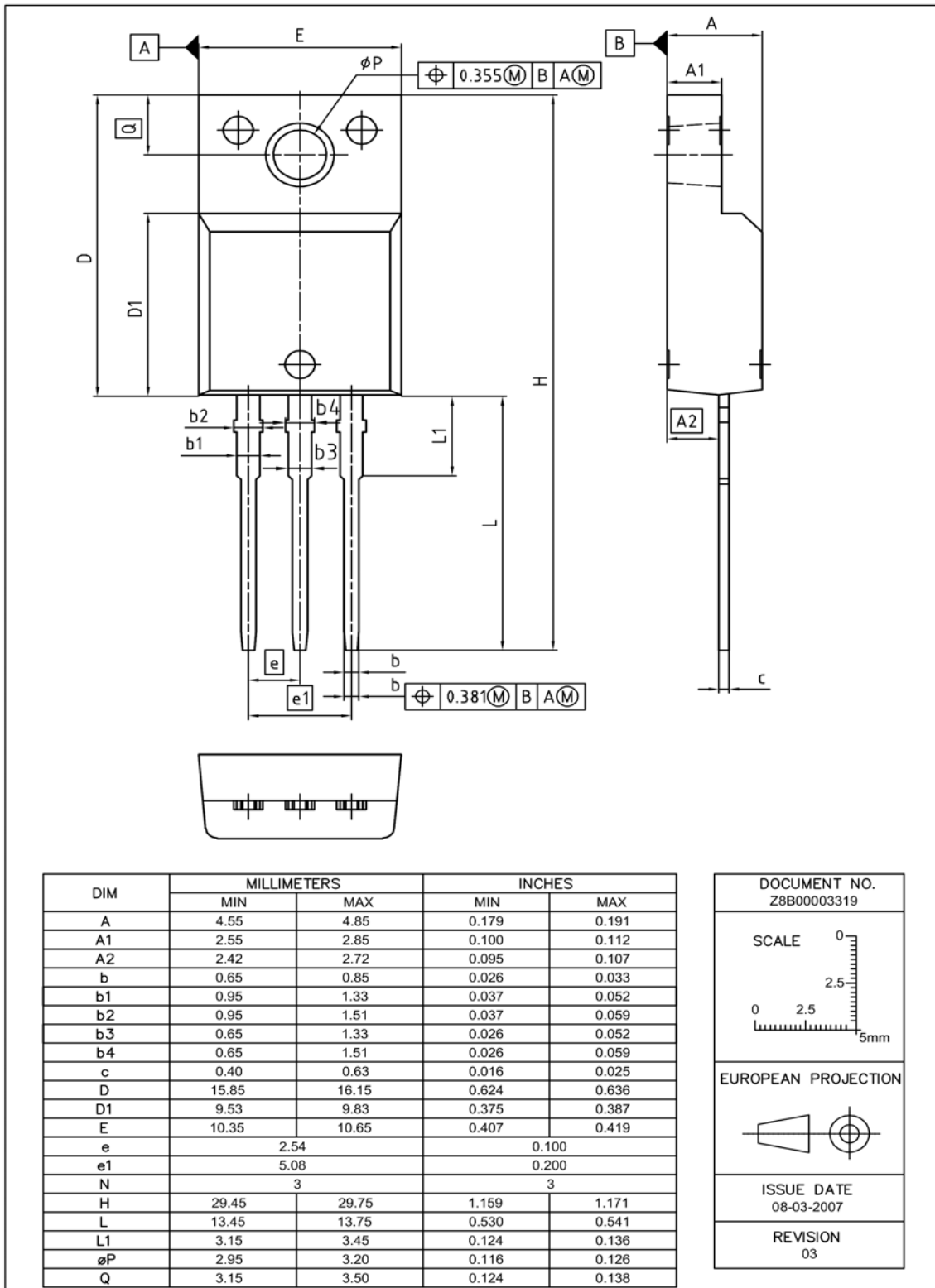
SCALE

EUROPEAN PROJECTION

ISSUE DATE
23-08-2007

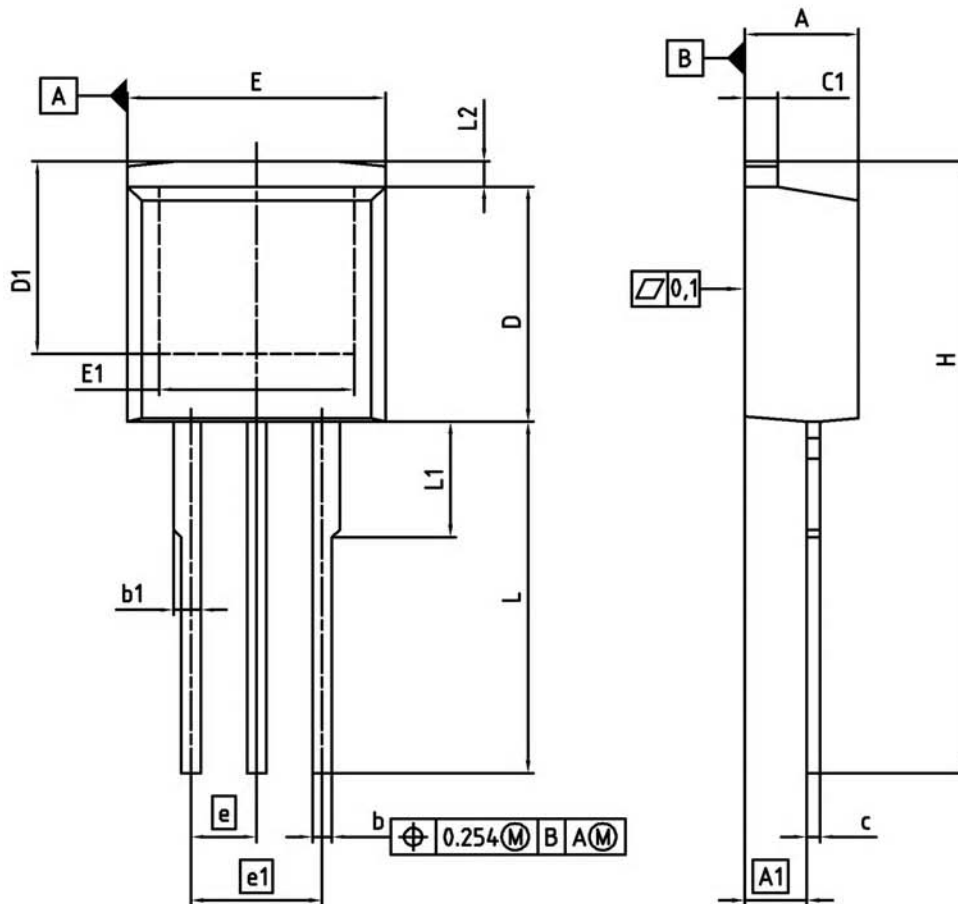
REVISION
05

PG-TO220-3 (Fully isolated)



Dimensions in mm/ inches

PG-TO262-3-1, PG-TO262-3-21 (I²-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 |

REFERENCE
JEDEC TO262

0 2.5 5mm

EUROPEAN PROJECTION

ISSUE DATE
05-05-2006

FILE
TO262_1



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