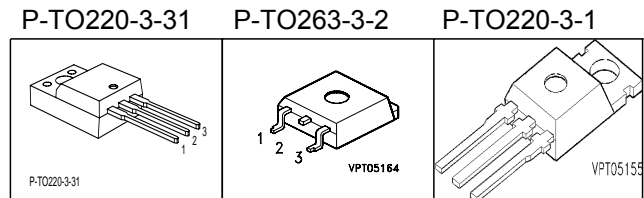


Cool MOS™ Power Transistor

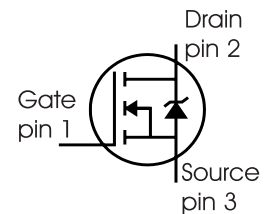
Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- P-TO-220-3-31: Fully isolated package (2500 VAC; 1 minute)

| | | |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 650 | V |
| $R_{DS(on)}$ | 0.95 | Ω |
| I_D | 4.5 | A |



| Type | Package | Ordering Code | Marking |
|------------|--------------|---------------|---------|
| SPP04N60C3 | P-TO220-3-1 | Q67040-S4366 | 04N60C3 |
| SPB04N60C3 | P-TO263-3-2 | Q67040-S4407 | 04N60C3 |
| SPA04N60C3 | P-TO220-3-31 | Q67040-S4413 | 04N60C3 |



Maximum Ratings

| Parameter | Symbol | Value | | Unit |
|---|--------------------|------------|--|-------------|
| | | SPP_B | SPA | |
| Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$ | I_D | 4.5 2.8 | 4.5 ¹⁾ 2.8 ¹⁾ | A |
| Pulsed drain current, t_p limited by T_{jmax} | $I_D \text{ puls}$ | 13.5 | 13.5 | A |
| Avalanche energy, single pulse $I_D=3.4, V_{DD}=50V$ | E_{AS} | 130 | 130 | mJ |
| Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=4.5A, V_{DD}=50V$ | E_{AR} | 0.4 | 0.4 | |
| Avalanche current, repetitive t_{AR} limited by T_{jmax} | I_{AR} | 4.5 | 4.5 | A |
| Gate source voltage static | V_{GS} | ± 20 | ± 20 | V |
| Gate source voltage AC ($f > 1\text{Hz}$) | V_{GS} | ± 30 | ± 30 | |
| Power dissipation, $T_C = 25\text{ °C}$ | P_{tot} | 50 | 31 | W |
| Operating and storage temperature | T_j, T_{stg} | -55...+150 | | °C |

Maximum Ratings

| Parameter | Symbol | Value | Unit |
|--|---------|-------|------|
| Drain Source voltage slope $V_{DS} = 480\text{ V}, I_D = 4.5\text{ A}, T_j = 125\text{ }^\circ\text{C}$ | dv/dt | 50 | V/ns |

Thermal Characteristics

| Parameter | Symbol | Values | | | Unit |
|---|----------------------|--------|------|------|------|
| | | min. | typ. | max. | |
| Thermal resistance, junction - case | R_{thJC} | - | - | 2.5 | 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 | |
| SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ³⁾ | R_{thJA} | - | - | 62 | |
| | | - | 35 | - | |
| Soldering temperature, 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 | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}, I_D=0.25\text{mA}$ | 600 | - | - | V |
| Drain-Source avalanche breakdown voltage | $V_{(BR)DS}$ | $V_{GS}=0\text{V}, I_D=4.5\text{A}$ | - | 700 | - | |
| Gate threshold voltage | $V_{GS(th)}$ | $I_D=200\mu\text{A}, V_{GS}=V_{DS}$ | 2.1 | 3 | 3.9 | |
| Zero gate voltage drain current | I_{DSS} | $V_{DS}=600\text{V}, V_{GS}=0\text{V},$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$ | - | 0.5 | 1 | μA |
| | | | - | - | 50 | |
| Gate-source leakage current | I_{GSS} | $V_{GS}=30\text{V}, V_{DS}=0\text{V}$ | - | - | 100 | nA |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}=10\text{V}, I_D=2.8\text{A}$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$ | - | 0.85 | 0.95 | Ω |
| | | | - | 2.3 | - | |
| Gate input resistance | R_G | $f=1\text{MHz}, \text{open drain}$ | - | 0.95 | - | |

Electrical Characteristics

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|--|--------|------|------|------|
| | | | min. | typ. | max. | |
| Transconductance | g_{fs} | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8A$ | - | 4.4 | - | S |
| Input capacitance | C_{iss} | $V_{GS} = 0V$, $V_{DS} = 25V$, $f = 1MHz$ | - | 490 | - | pF |
| Output capacitance | C_{oss} | | - | 160 | - | |
| Reverse transfer capacitance | C_{rss} | | - | 15 | - | |
| Effective output capacitance, ⁵⁾ energy related | $C_{o(er)}$ | $V_{GS} = 0V$, $V_{DS} = 0V$ to 480V | - | 20 | - | |
| Effective output capacitance, ⁶⁾ time related | $C_{o(tr)}$ | | - | 35 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 380V$, $V_{GS} = 0/10V$, $I_D = 4.5A$, $R_G = 18\Omega$ | - | 6 | - | ns |
| Rise time | t_r | | - | 2.5 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 58.5 | 80 | |
| Fall time | t_f | | - | 9.5 | 14 | |

Gate Charge Characteristics

| | | | | | | |
|-----------------------|-----------------|---|---|-----|----|----|
| Gate to source charge | Q_{gs} | $V_{DD} = 480V$, $I_D = 4.5A$ | - | 2.2 | - | nC |
| Gate to drain charge | Q_{gd} | | - | 8.8 | - | |
| Gate charge total | Q_g | $V_{DD} = 480V$, $I_D = 4.5A$, $V_{GS} = 0$ to 10V | - | 19 | 25 | |
| Gate plateau voltage | $V_{(plateau)}$ | $V_{DD} = 480V$, $I_D = 4.5A$ | - | 5 | - | V |

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} .

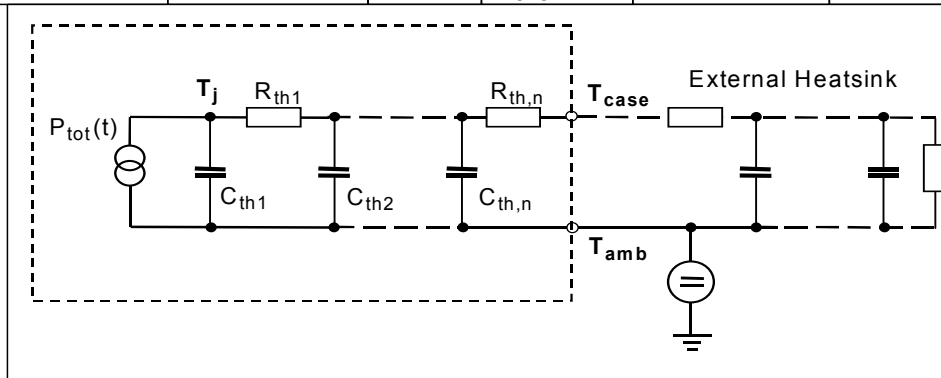
⁶ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|-----------------------------------|--------|------|------|------------------------|
| | | | min. | typ. | max. | |
| Inverse diode continuous forward current | I_S | $T_C=25^\circ\text{C}$ | - | - | 4.5 | A |
| Inverse diode direct current, pulsed | I_{SM} | | - | - | 13.5 | |
| Inverse diode forward voltage | V_{SD} | $V_{GS}=0\text{V}, I_F=I_S$ | - | 1 | 1.2 | V |
| Reverse recovery time | t_{rr} | $V_R=480\text{V}, I_F=I_S,$ | - | 300 | 500 | ns |
| Reverse recovery charge | Q_{rr} | $di_F/dt=100\text{A}/\mu\text{s}$ | - | 2.6 | - | μC |
| Peak reverse recovery current | I_{rrm} | | - | 18 | - | A |
| Peak rate of fall of reverse recovery current | di_{rr}/dt | $T_j=25^\circ\text{C}$ | - | 900 | - | $\text{A}/\mu\text{s}$ |

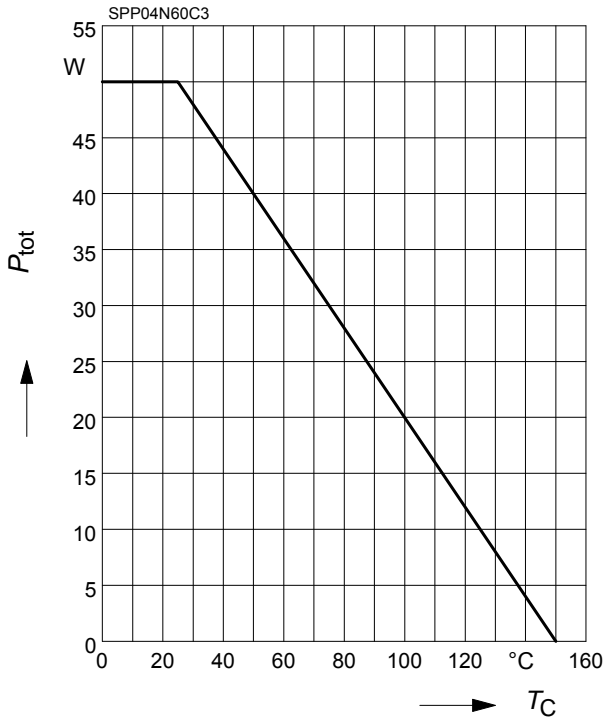
Typical Transient Thermal Characteristics

| Symbol | Value | | Unit | Symbol | Value | | Unit |
|-----------|-------|-------|------|-----------|------------|------------|------|
| | SPP_B | SPA | | | SPP_B | SPA | |
| R_{th1} | 0.039 | 0.039 | K/W | C_{th1} | 0.00007347 | 0.00007347 | Ws/K |
| R_{th2} | 0.074 | 0.074 | | C_{th2} | 0.0002831 | 0.0002831 | |
| R_{th3} | 0.132 | 0.132 | | C_{th3} | 0.0004062 | 0.0004062 | |
| R_{th4} | 0.555 | 0.272 | | C_{th4} | 0.001215 | 0.001215 | |
| R_{th5} | 0.529 | 0.559 | | C_{th5} | 0.00276 | 0.005633 | |
| R_{th6} | 0.169 | 2.523 | | C_{th6} | 0.029 | 0.412 | |



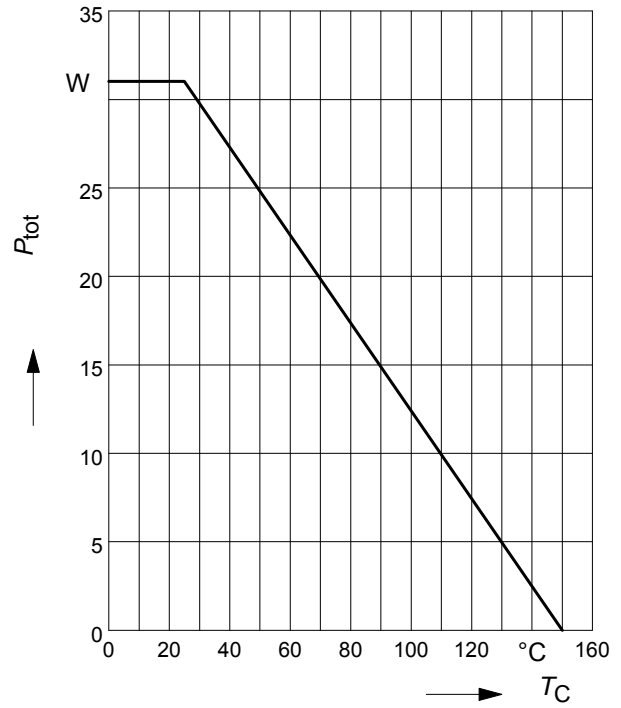
1 Power dissipation

$P_{tot} = f(T_C)$



2 Power dissipation FullPAK

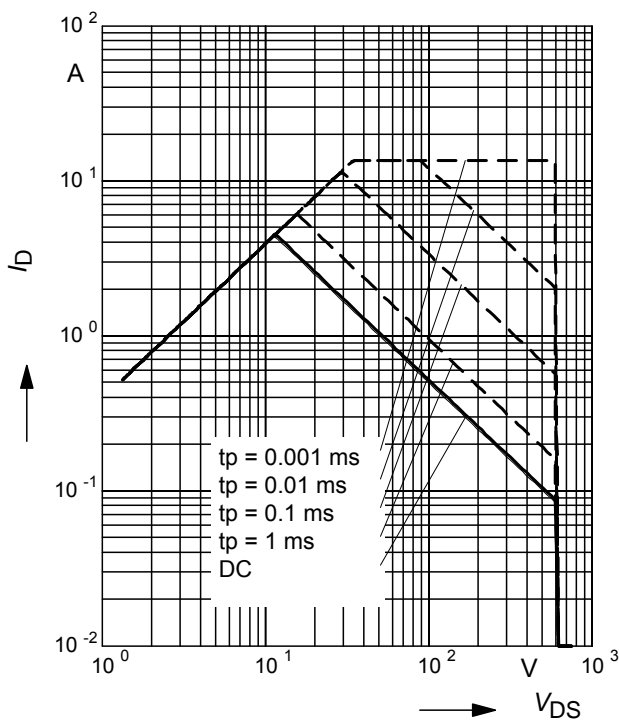
$P_{tot} = f(T_C)$



3 Safe operating area

$I_D = f(V_{DS})$

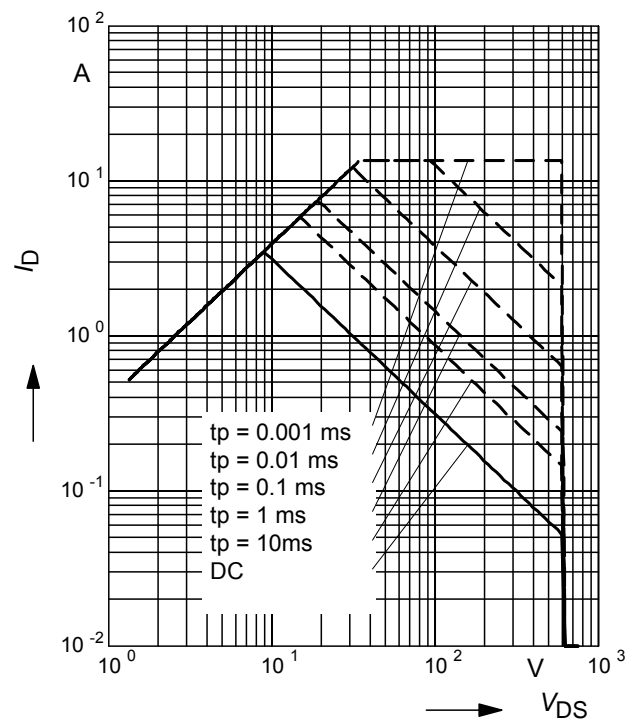
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

$I_D = f(V_{DS})$

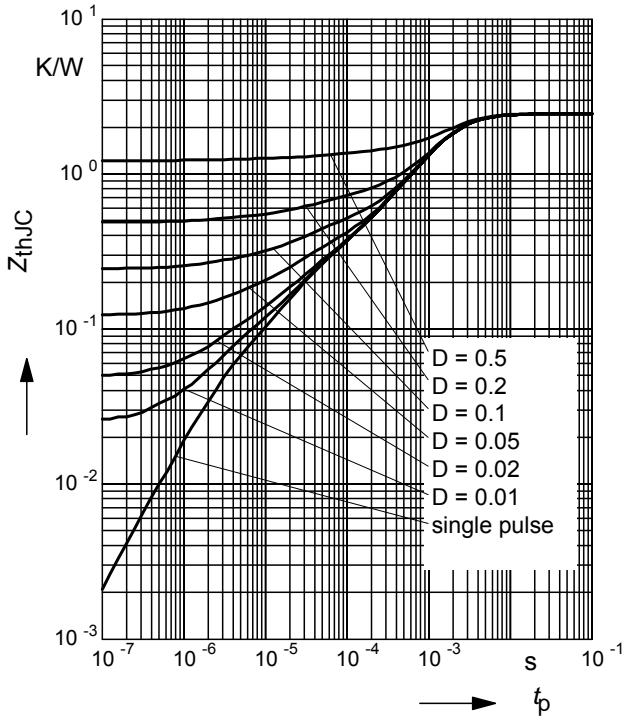
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

$Z_{thJC} = f(t_p)$

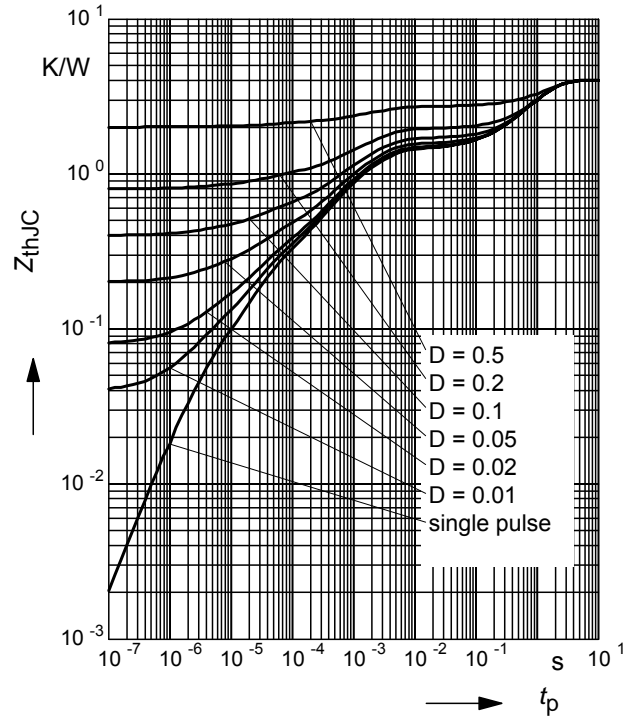
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

$Z_{thJC} = f(t_p)$

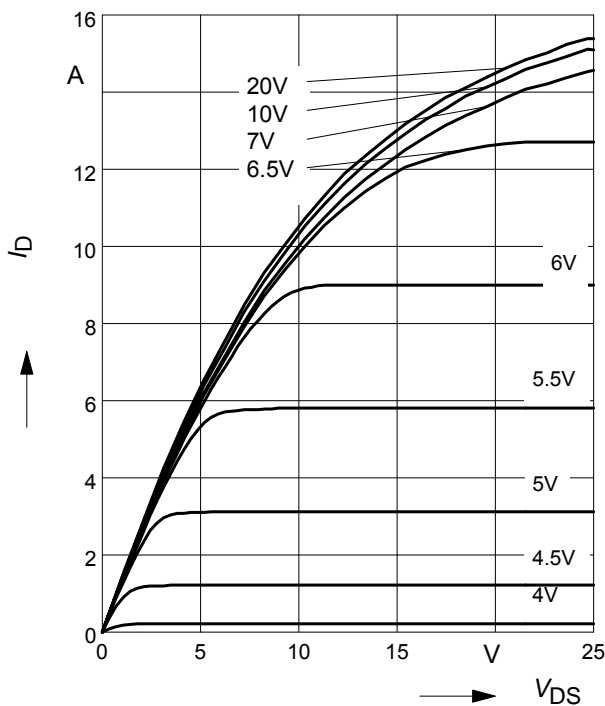
parameter: $D = t_p/t$



7 Typ. output characteristic

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

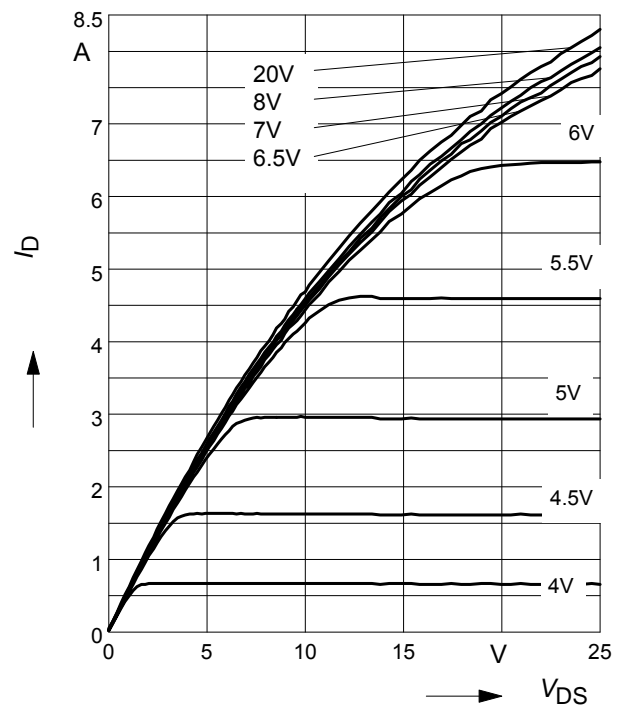
parameter: $t_p = 10 \mu s, V_{GS}$



8 Typ. output characteristic

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

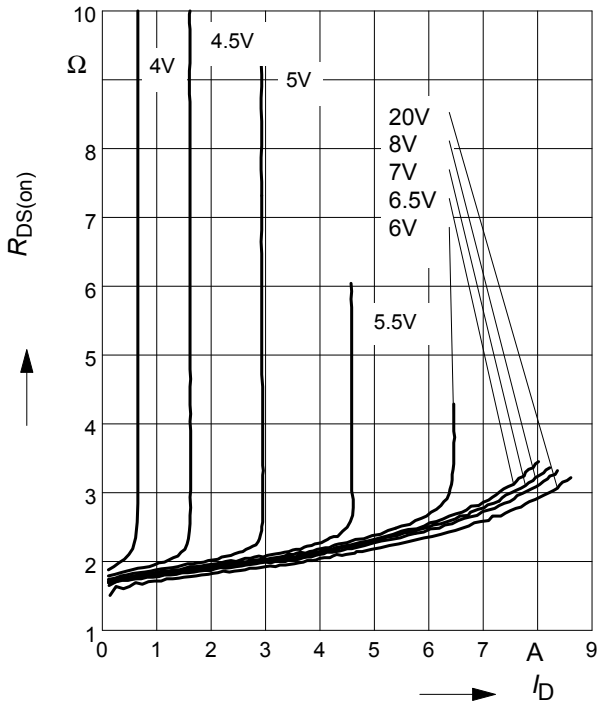
parameter: $t_p = 10 \mu s, V_{GS}$



9 Typ. drain-source on resistance

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

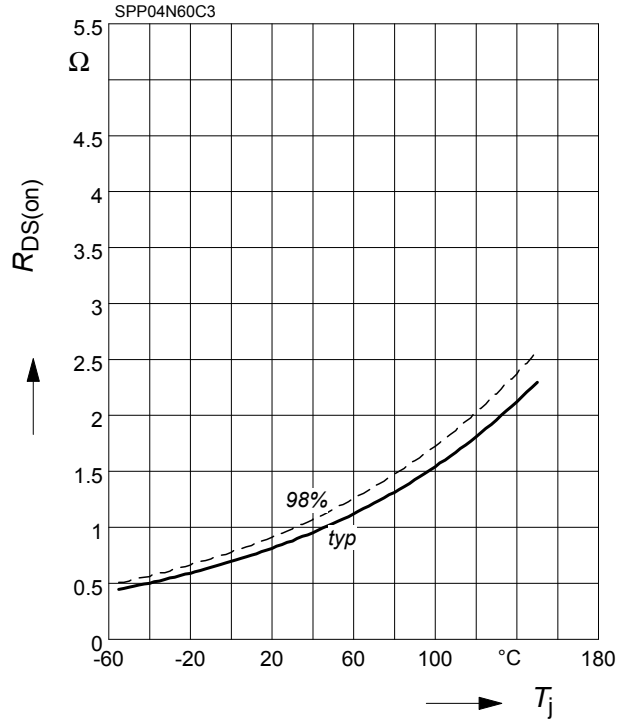
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

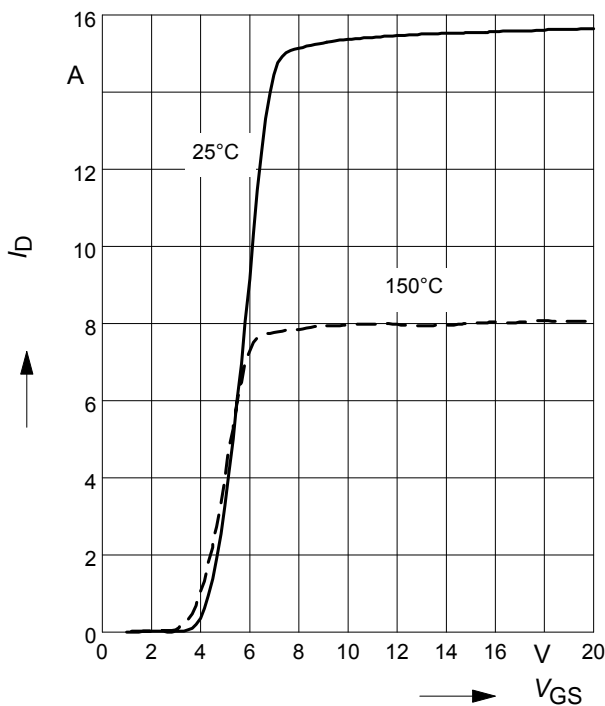
parameter: $I_D = 2.8\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

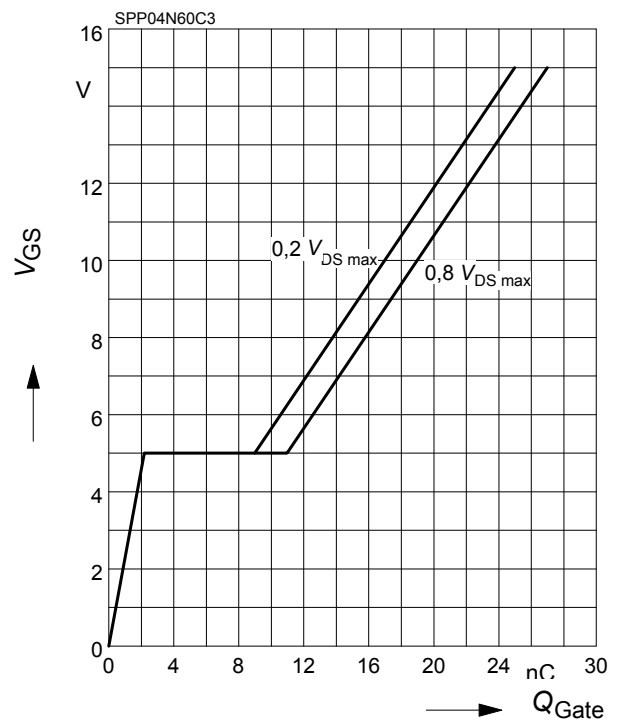
parameter: $t_p = 10\ \mu\text{s}$



12 Typ. gate charge

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

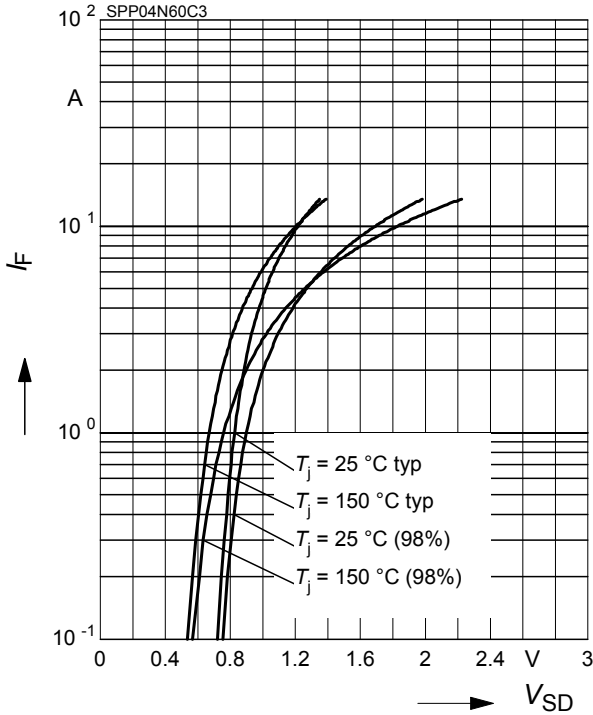
parameter: $I_D = 4.5\text{ A pulsed}$



13 Forward characteristics of body diode

$I_F = f(V_{SD})$

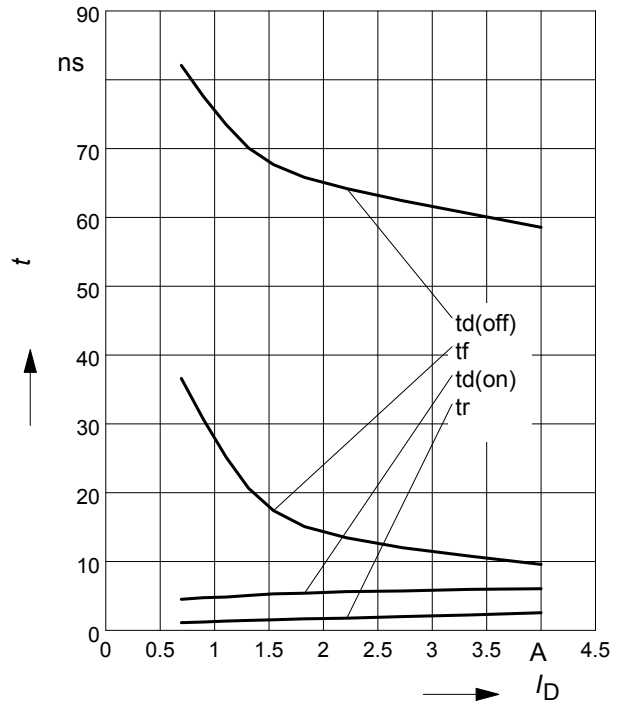
parameter: T_j , $t_p = 10 \mu s$



14 Typ. switching time

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

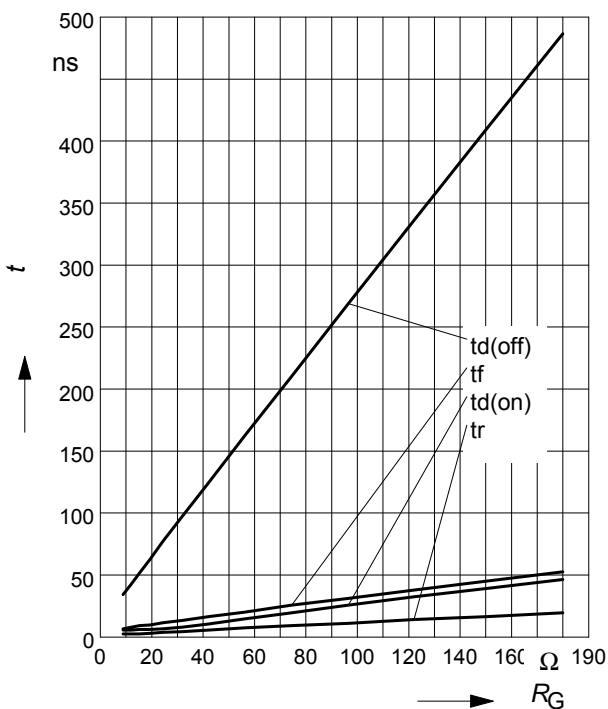
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $R_G = 18\Omega$



15 Typ. switching time

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

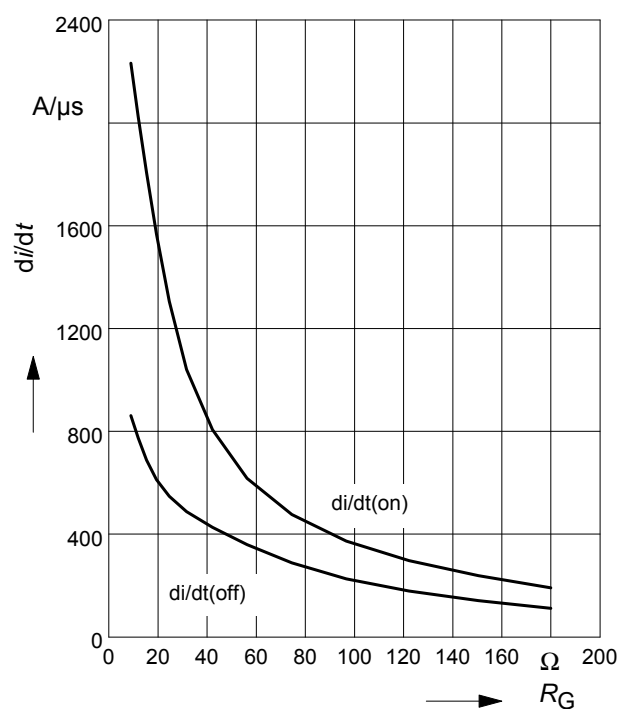
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $I_D = 4.5 A$



16 Typ. drain current slope

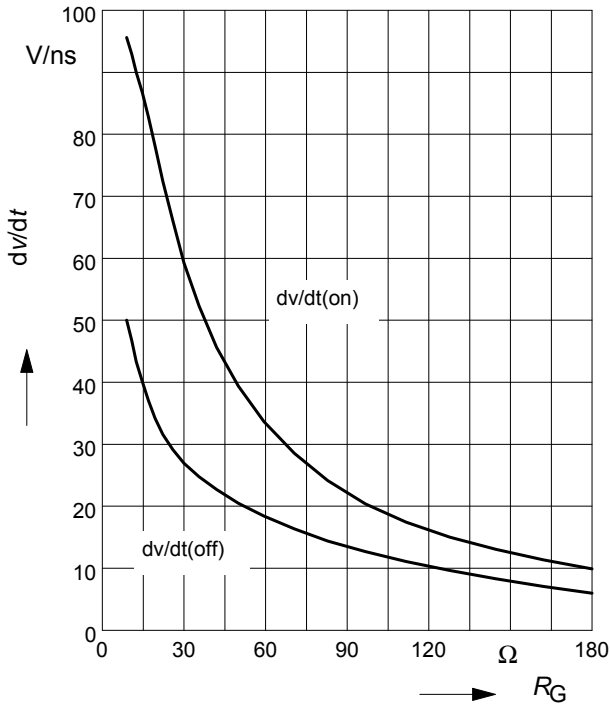
$di/dt = f(R_G)$, inductive load, $T_j = 125^\circ C$

par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $I_D = 4.5A$



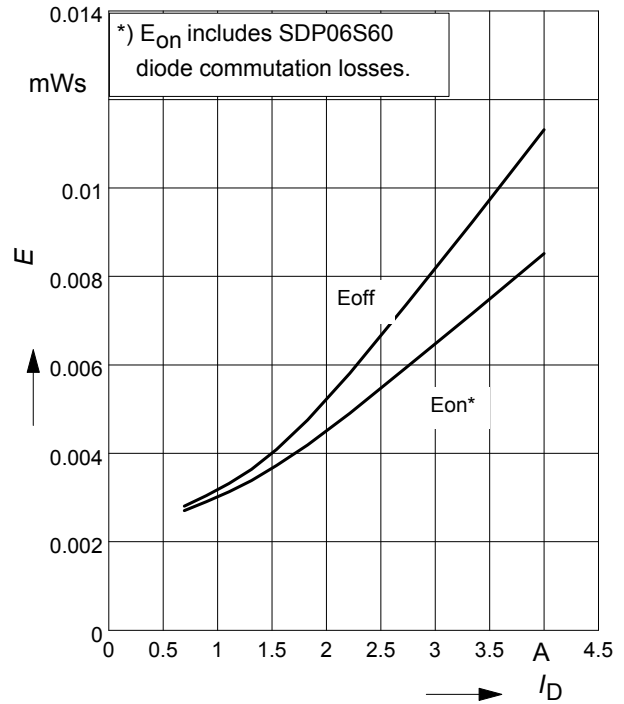
17 Typ. drain source voltage slope

$dv/dt = f(R_G)$, inductive load, $T_j = 125^\circ\text{C}$
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



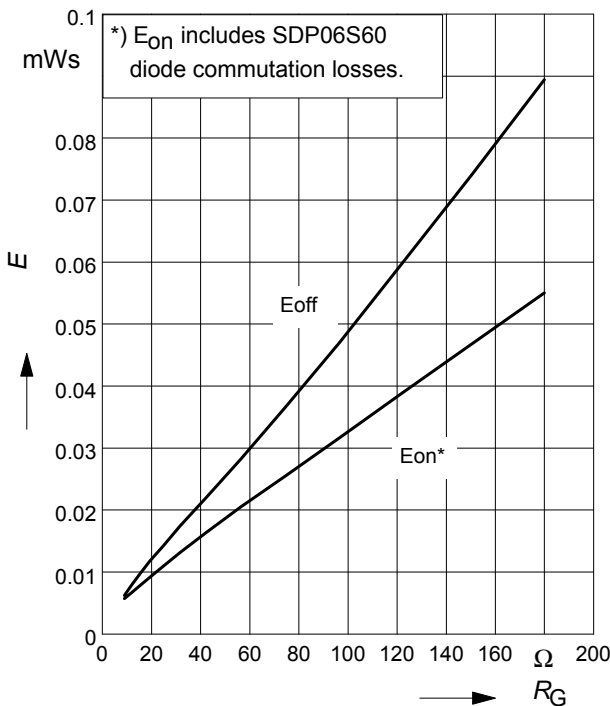
18 Typ. switching losses

$E = f(I_D)$, inductive load, $T_j=125^\circ\text{C}$
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $R_G=18\Omega$



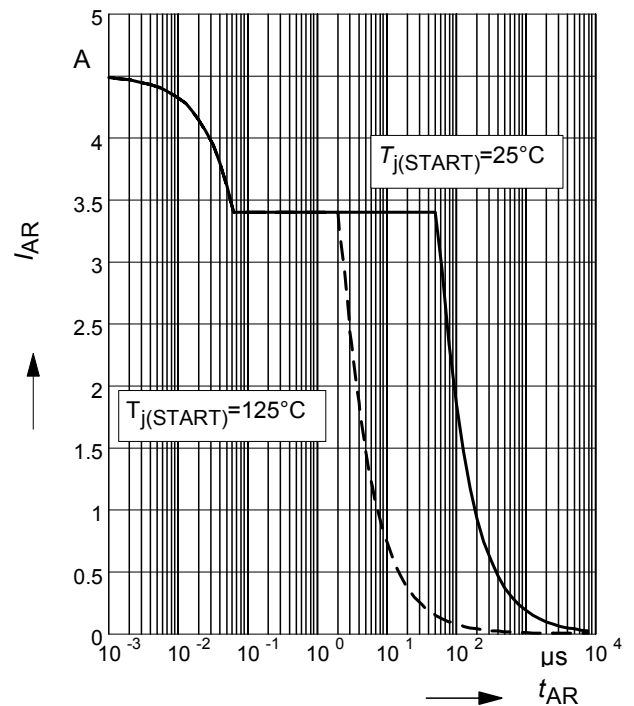
19 Typ. switching losses

$E = f(R_G)$, inductive load, $T_j=125^\circ\text{C}$
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



20 Avalanche SOA

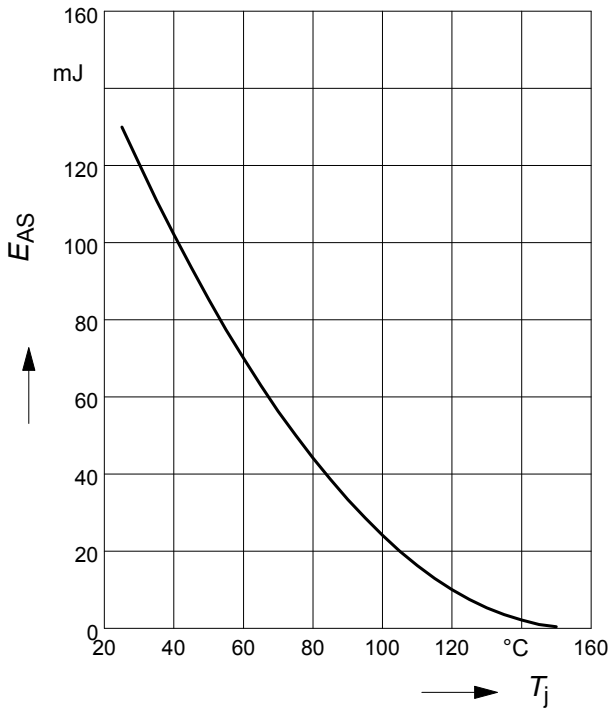
$I_{AR} = f(t_{AR})$
par.: $T_j \leq 150^\circ\text{C}$



21 Avalanche energy

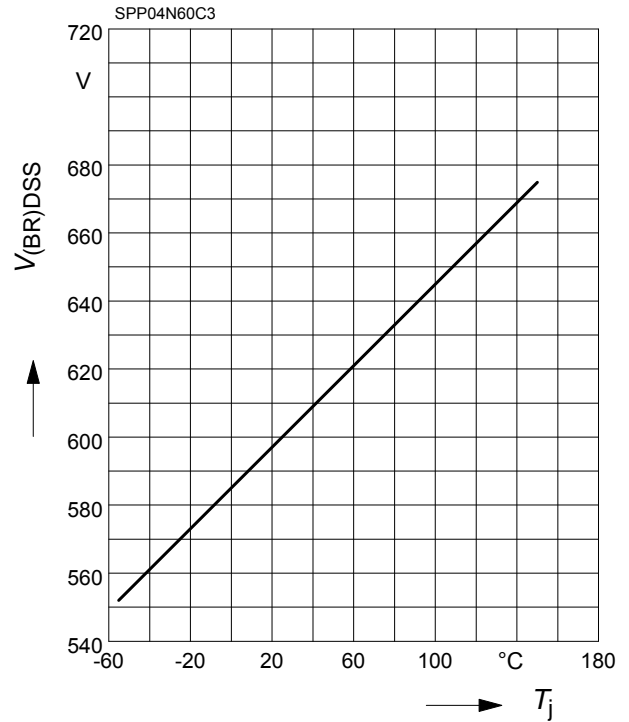
$$E_{AS} = f(T_j)$$

par.: $I_D = 3.4$, $V_{DD} = 50$ V



22 Drain-source breakdown voltage

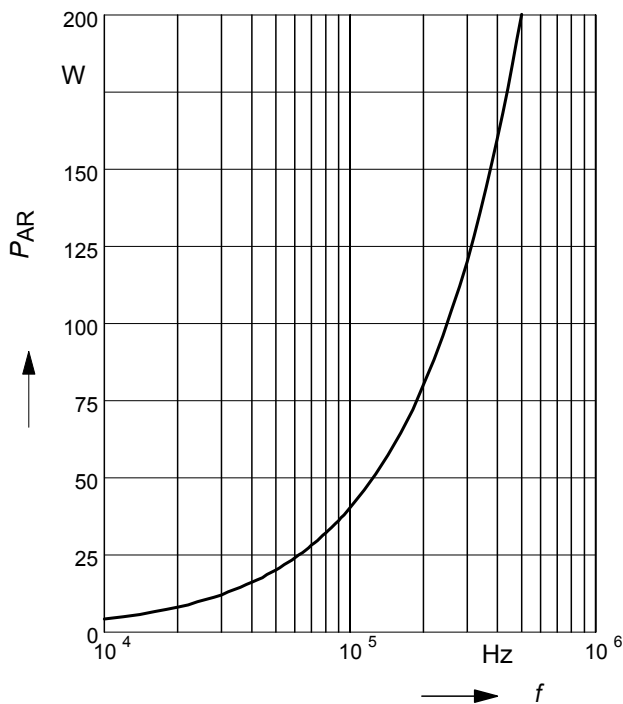
$$V_{(BR)DSS} = f(T_j)$$



23 Avalanche power losses

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

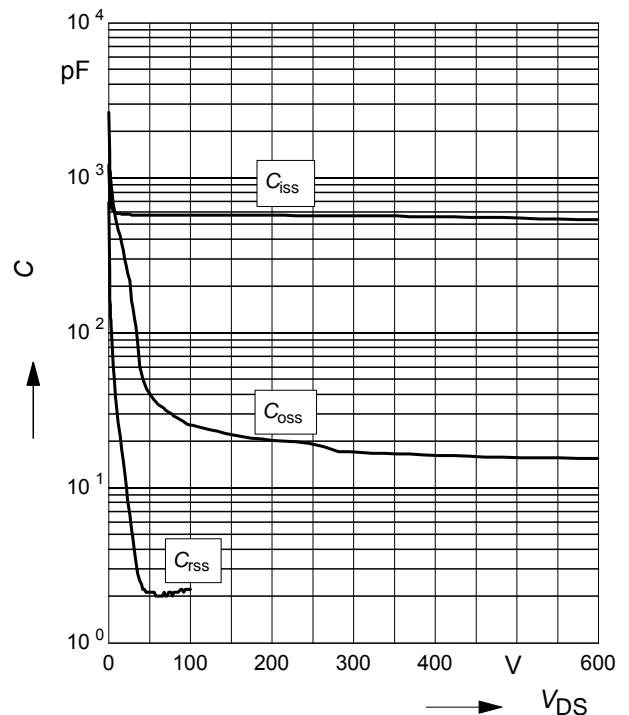
parameter: $E_{AR}=0.4$ mJ



24 Typ. capacitances

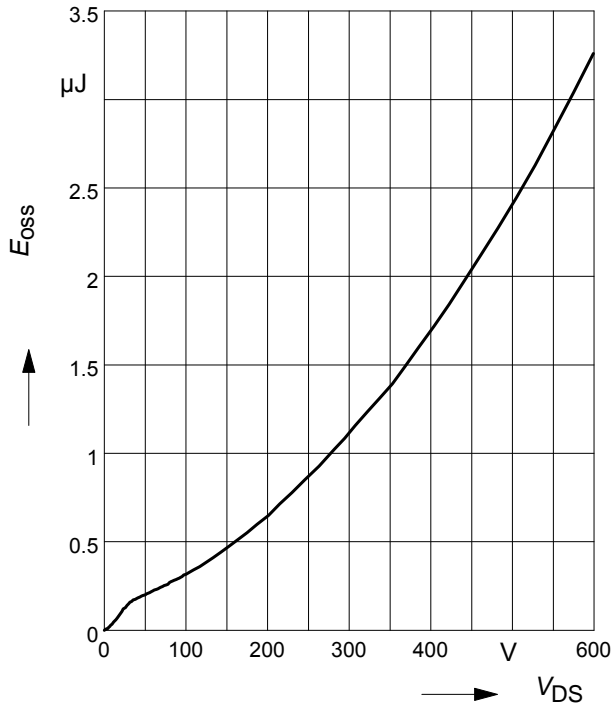
$$C = f(V_{DS})$$

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

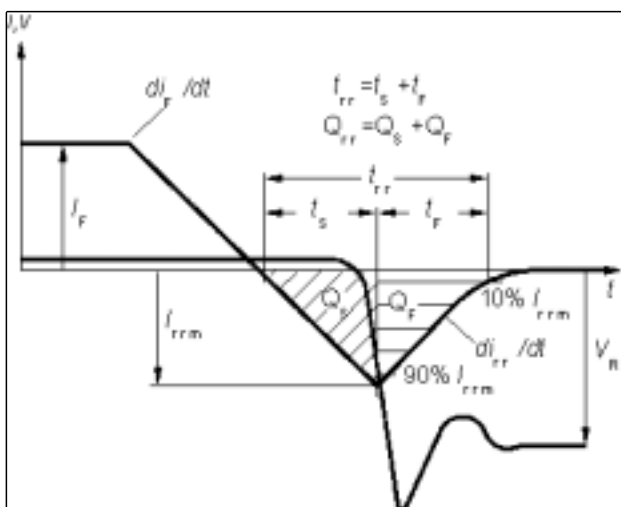


25 Typ. C_{OSS} stored energy

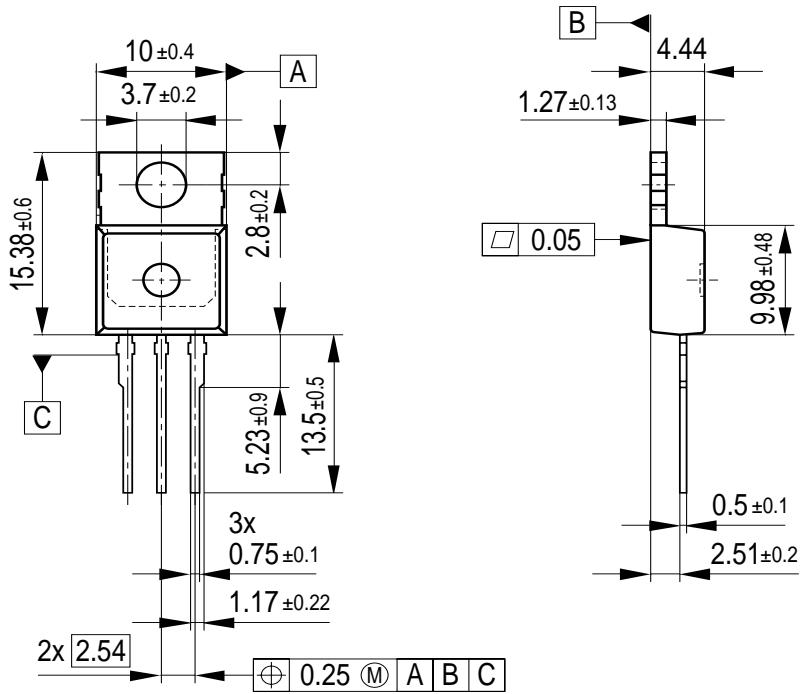
$$E_{OSS} = f(V_{DS})$$



Definition of diodes switching characteristics

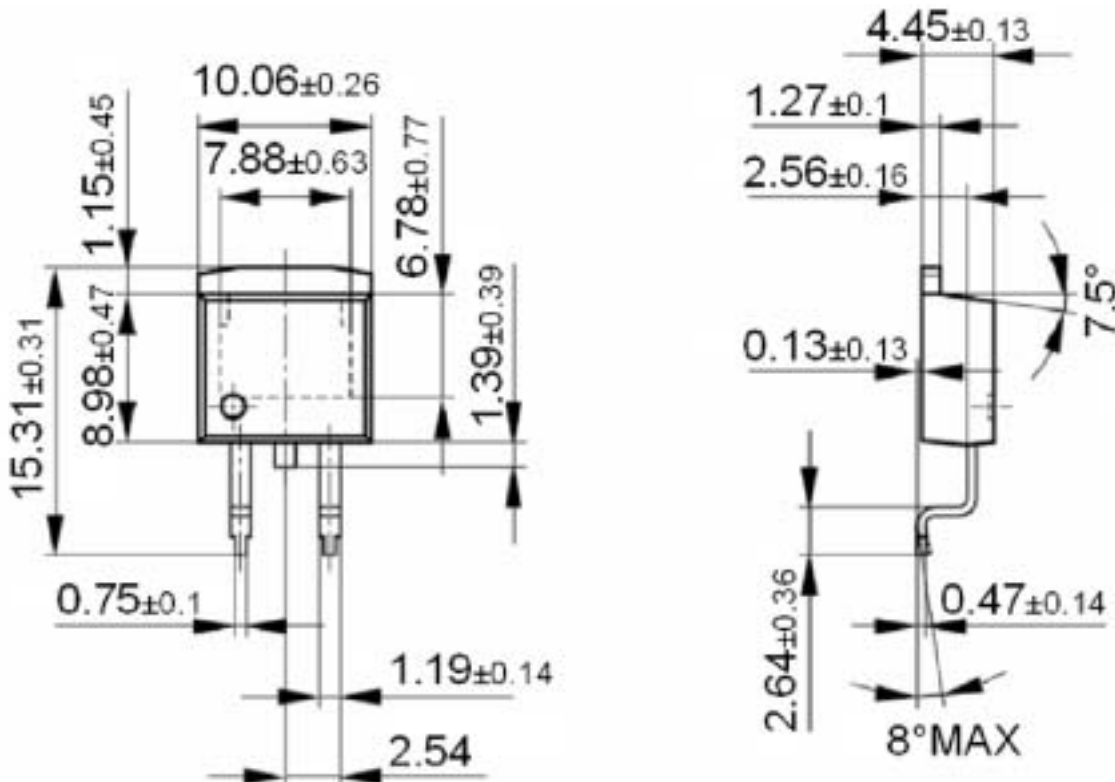


P-TO-220-3-1

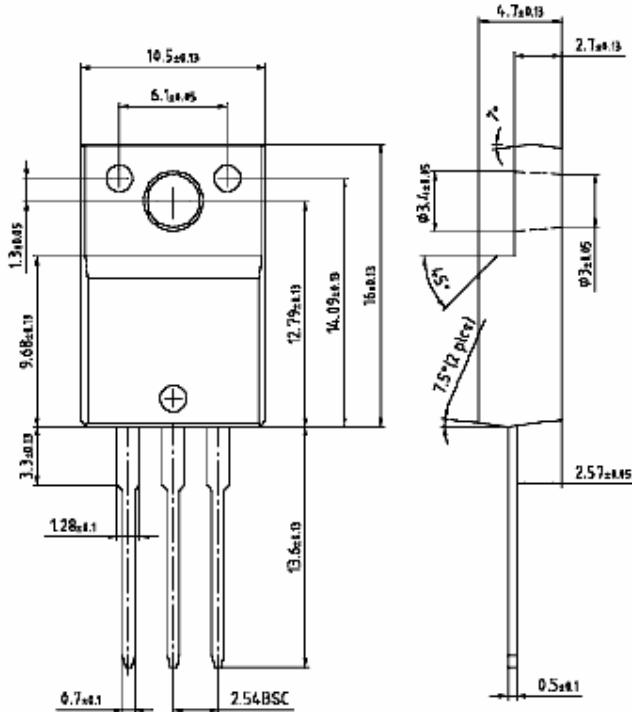


All metal surfaces tin plated, except area of cut.
Metal surface min. x=7.25, y=12.3

P-TO-263-3-2 (D²-PAK)



P-TO-220-3-31 (FullPAK)



Please refer to mounting instructions (application note AN-TO220-3-31-01)

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