

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
- Pb-free lead plating; RoHS compliant; Halogen free mold compound^{a)}
- Qualified according to JEDEC⁰⁾ for target applications

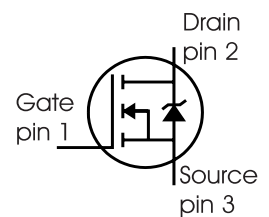
| | | |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 650 | V |
| $R_{DS(on)}$ | 0.95 | Ω |
| I_D | 4.5 | A |



PG-TO251-3-11



| Type | Package | Marking |
|------------|---------------|---------|
| SPS04N60C3 | PG-TO251-3-11 | 04N60C3 |


Maximum Ratings

| Parameter | Symbol | Value | Unit |
|--|--------------------|-------------|------------------|
| Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$ | I_D | 4.5 2.8 | A |
| Pulsed drain current, t_p limited by T_{jmax} | $I_D \text{ puls}$ | 13.5 | |
| Avalanche energy, single pulse $I_D = 3.4\text{ A}$, $V_{DD} = 50\text{ V}$ | E_{AS} | 130 | mJ |
| Avalanche energy, repetitive t_{AR} limited by T_{jmax} ¹⁾ $I_D = 4.5\text{ A}$, $V_{DD} = 50\text{ V}$ | E_{AR} | 0.4 | |
| Avalanche current, repetitive t_{AR} limited by T_{jmax} | I_{AR} | 4.5 | A |
| Gate source voltage static | V_{GS} | ± 20 | V |
| Gate source voltage AC ($f > 1\text{ Hz}$) | V_{GS} | ± 30 | |
| Power dissipation, $T_C = 25\text{ }^\circ\text{C}$ | P_{tot} | 50 | W |
| Operating and storage temperature | T_j, T_{stg} | -55... +150 | $^\circ\text{C}$ |
| Reverse diode dv/dt ⁵⁾ | dv/dt | 15 | V/ns |

^{a)} non-Halogen free (OPN: SPS04N60C3BT); Halogen free (OPN: SPS04N60C3AT)

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 - ambient, leaded | R_{thJA} | - | - | 75 | |
| SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ²⁾ | R_{thJA} | - | - | 75 50 | |
| Soldering temperature, wavesoldering 1.6 mm (0.063 in.) from case for 10s | 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 | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$ | 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 50 | μA |
| 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 2.3 | 0.95 - | Ω |
| Gate input resistance | R_G | $f=1\text{MHz}$, open Drain | - | 0.95 | - | |

Electrical Characteristics , at $T_j = 25\text{ }^\circ\text{C}$, unless otherwise specified

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|--------------|--|--------|------|------|------|
| | | | min. | typ. | max. | |
| Transconductance | g_{fs} | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8\text{A}$ | - | 4.4 | - | S |
| Input capacitance | C_{iss} | $V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1\text{MHz}$ | - | 490 | - | pF |
| Output capacitance | C_{oss} | | - | 160 | - | |
| Reverse transfer capacitance | C_{rss} | | - | 15 | - | |
| Effective output capacitance, ³⁾ energy related | $C_{o(er)}$ | $V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V to } 480\text{V}$ | - | 20 | - | pF |
| Effective output capacitance, ⁴⁾ time related | $C_{o(tr)}$ | | - | 35 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 380\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 4.5\text{A}$, $R_G = 18\Omega$ | - | 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} | $V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$ | - | 2.2 | - | nC |
| Gate to drain charge | Q_{gd} | | - | 8.8 | - | |
| Gate charge total | Q_g | $V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$, $V_{GS} = 0\text{ to } 10\text{V}$ | - | 19 | 25 | |
| Gate plateau voltage | $V_{(plateau)}$ | $V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$ | - | 5 | - | V |

⁰J-STD20 and JESD22

¹Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

²Device 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.

³ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

⁴ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

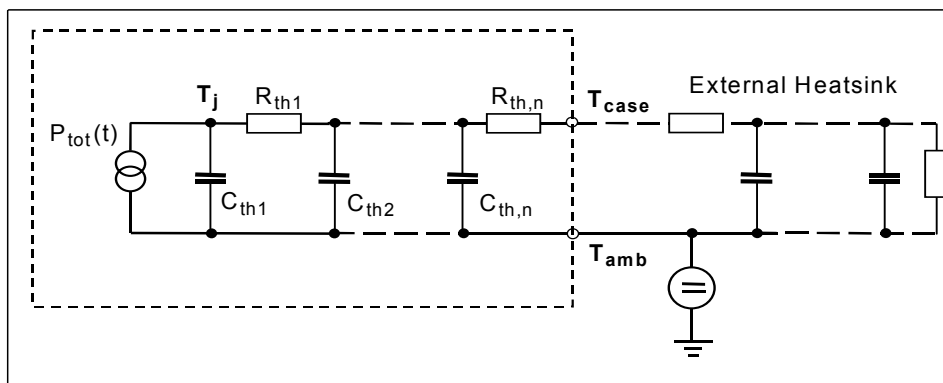
⁵ $I_{SD} \leq I_D$, $di/dt \leq 400\text{A/us}$, $V_{DClink} = 400\text{V}$, $V_{peak} < V_{BR, DSS}$, $T_j < T_{j,max}$.
Identical low-side and high-side switch.

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 | $T_C=25^\circ\text{C}$ | - | - | 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 | | - | - | 900 | $\text{A}/\mu\text{s}$ |

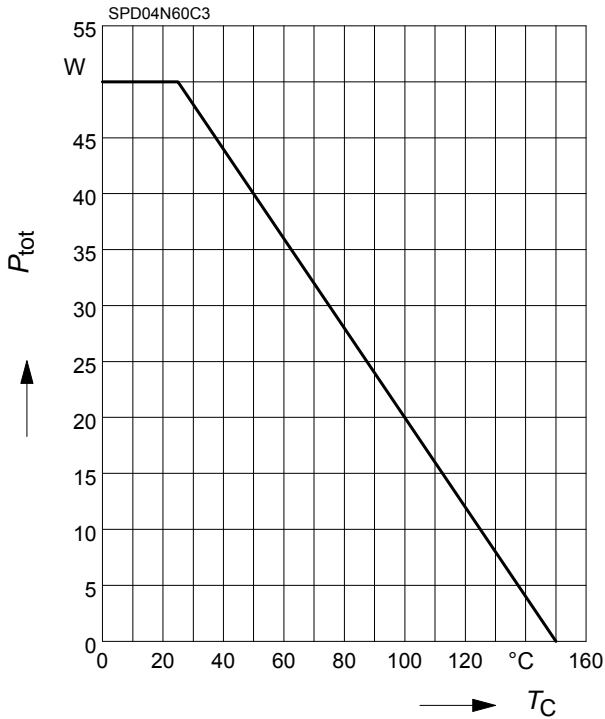
Typical Transient Thermal Characteristics

| Symbol | Value | Unit | Symbol | Value | Unit |
|--------------------|-------|------|---------------------|------------|------|
| | typ. | | | typ. | |
| Thermal resistance | | | Thermal capacitance | | |
| R_{th1} | 0.039 | K/W | C_{th1} | 0.00007347 | Ws/K |
| R_{th2} | 0.074 | | C_{th2} | 0.0002831 | |
| R_{th3} | 0.132 | | C_{th3} | 0.0004062 | |
| R_{th4} | 0.555 | | C_{th4} | 0.001215 | |
| R_{th5} | 0.529 | | C_{th5} | 0.00276 | |
| R_{th6} | 0.169 | | C_{th6} | 0.029 | |



1 Power dissipation

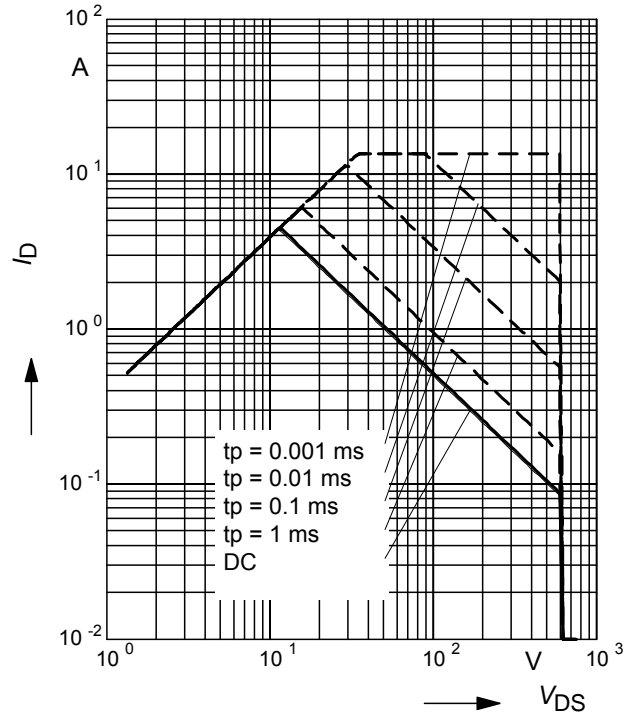
$P_{tot} = f(T_C)$



2 Safe operating area

$I_D = f(V_{DS})$

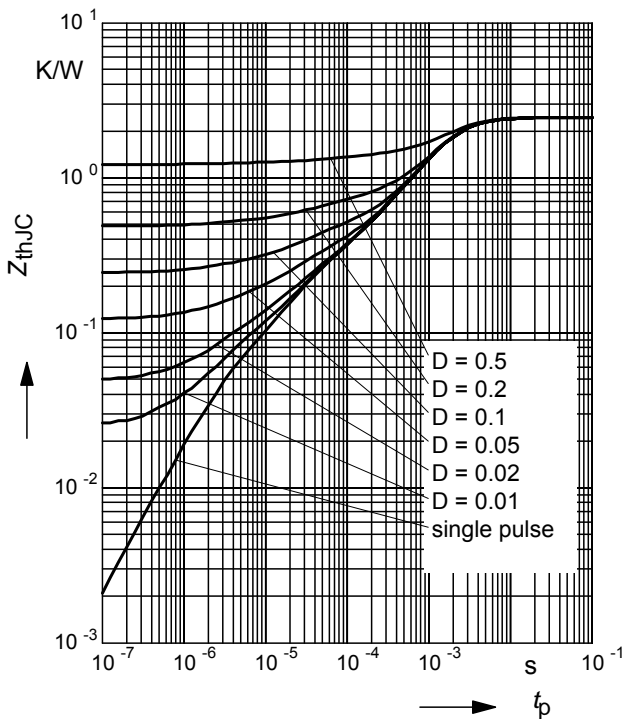
parameter : $D = 0, T_C = 25^\circ C$



3 Transient thermal impedance

$Z_{thJC} = f(t_p)$

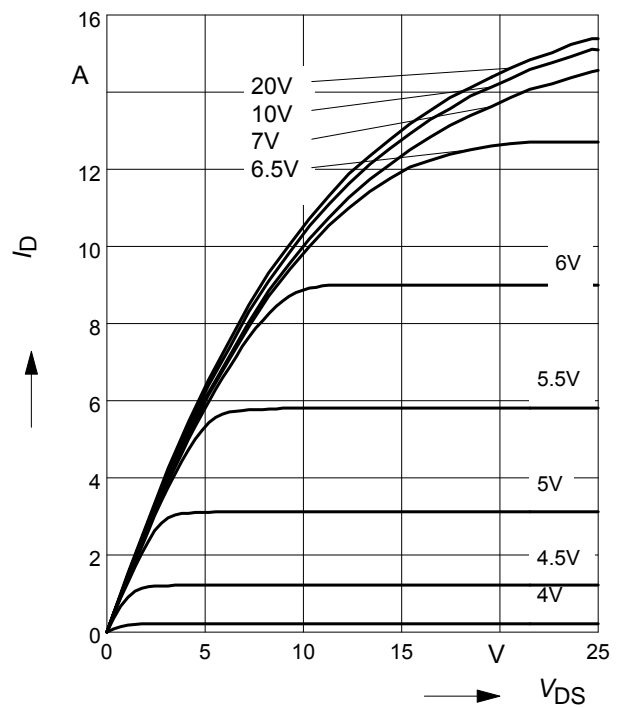
parameter: $D = t_p/T$



4 Typ. output characteristic

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

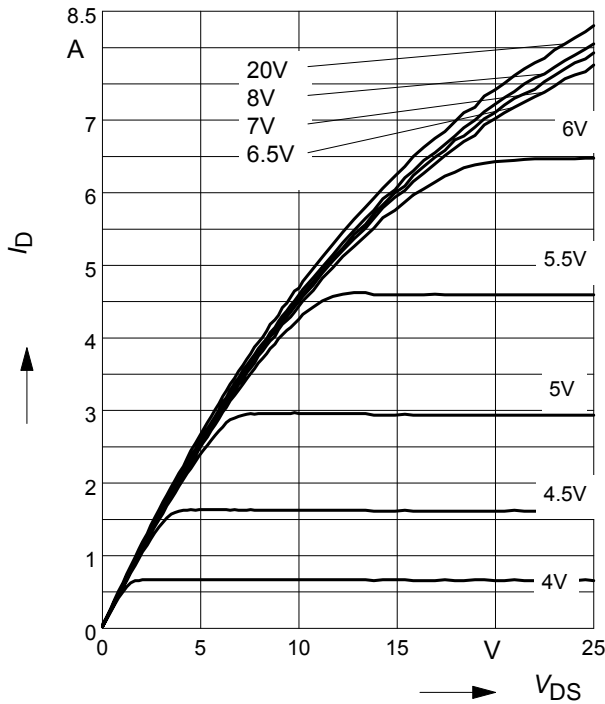
parameter: $t_p = 10 \mu s, V_{GS}$



5 Typ. output characteristic

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

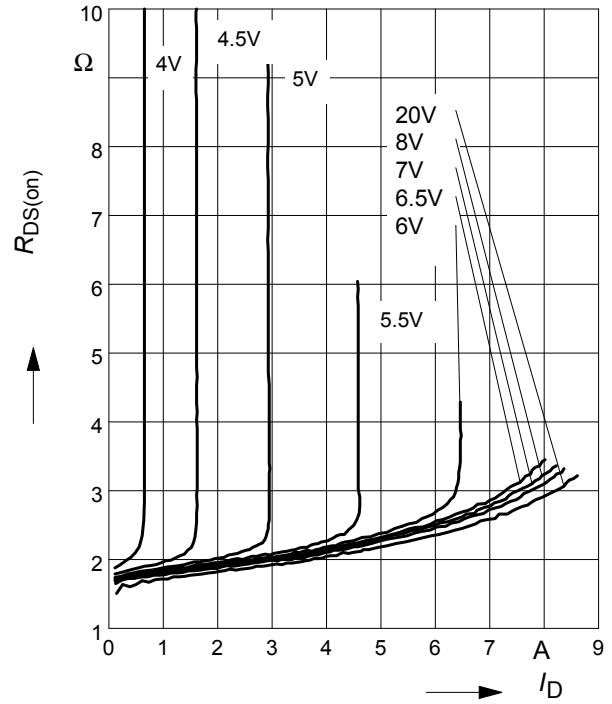
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



6 Typ. drain-source on resistance

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

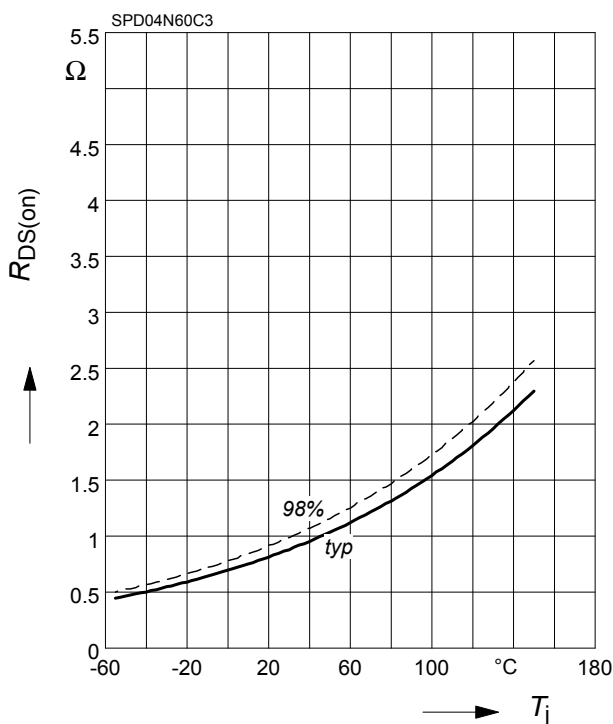
parameter: $T_j = 150^\circ\text{C}, V_{GS}$



7 Drain-source on-state resistance

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

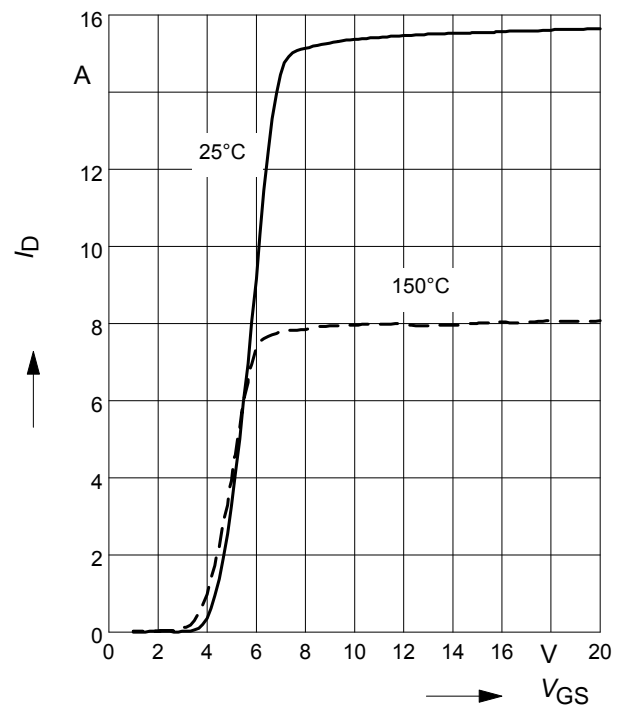
parameter: $I_D = 2.8 \text{ A}, V_{GS} = 10 \text{ V}$



8 Typ. transfer characteristics

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

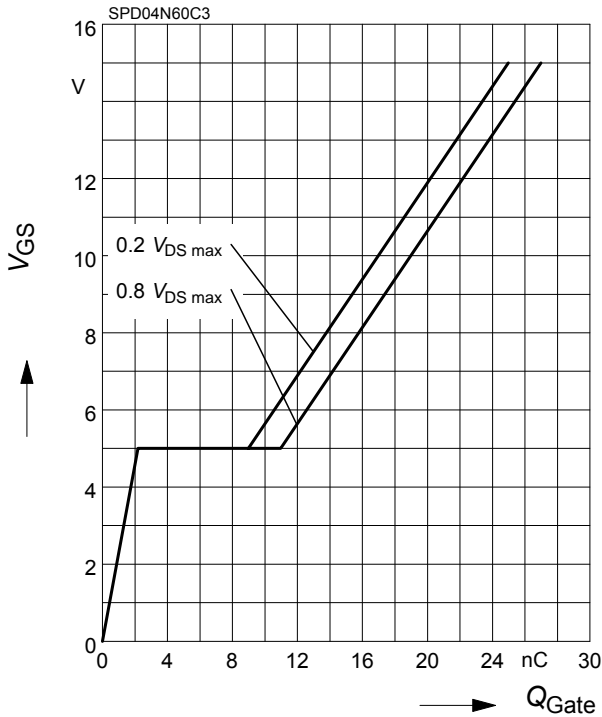
parameter: $t_p = 10 \mu\text{s}$



9 Typ. gate charge

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

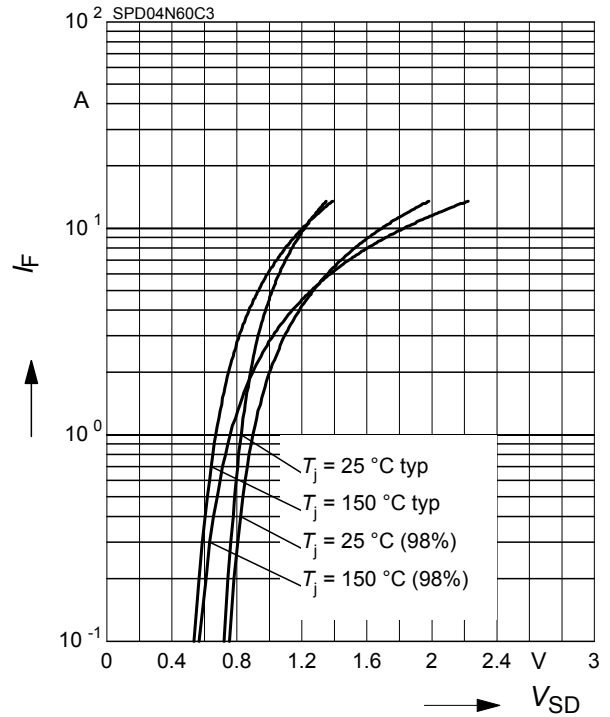
parameter: $I_D = 4.5\text{ A}$ pulsed



10 Forward characteristics of body diode

$I_F = f(V_{SD})$

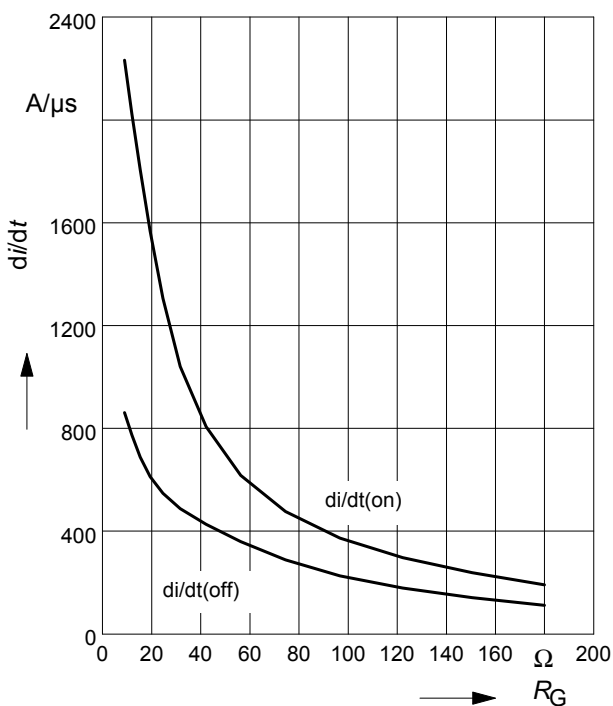
parameter: $T_j, t_p = 10\ \mu\text{s}$



11 Typ. drain current slope

$di/dt = f(R_G)$, inductive load, $T_j = 125\text{ °C}$

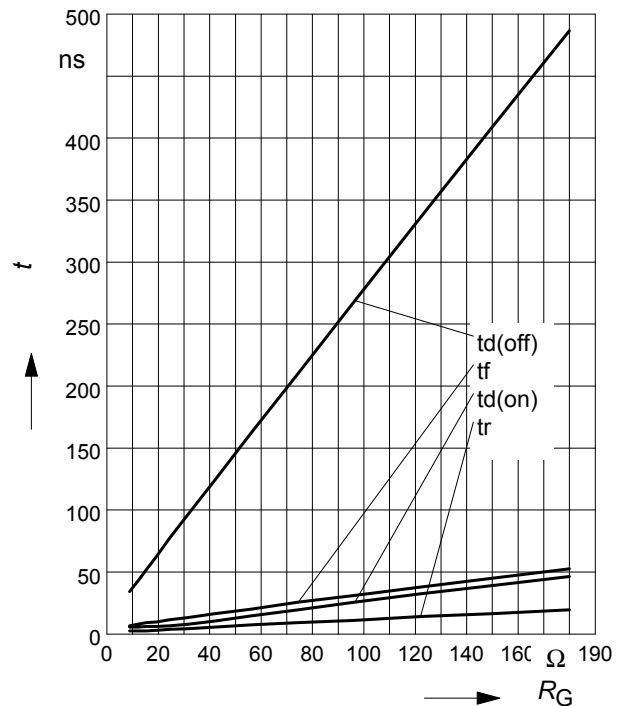
par.: $V_{DS}=380\text{V}, V_{GS}=0/+13\text{V}, I_D=4.5\text{A}$



12 Typ. switching time

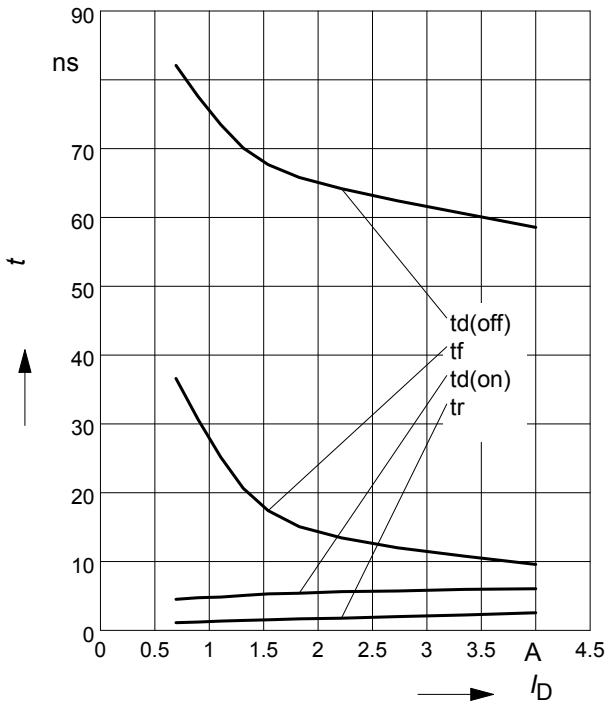
$t = f(R_G)$, inductive load, $T_j=125\text{ °C}$

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



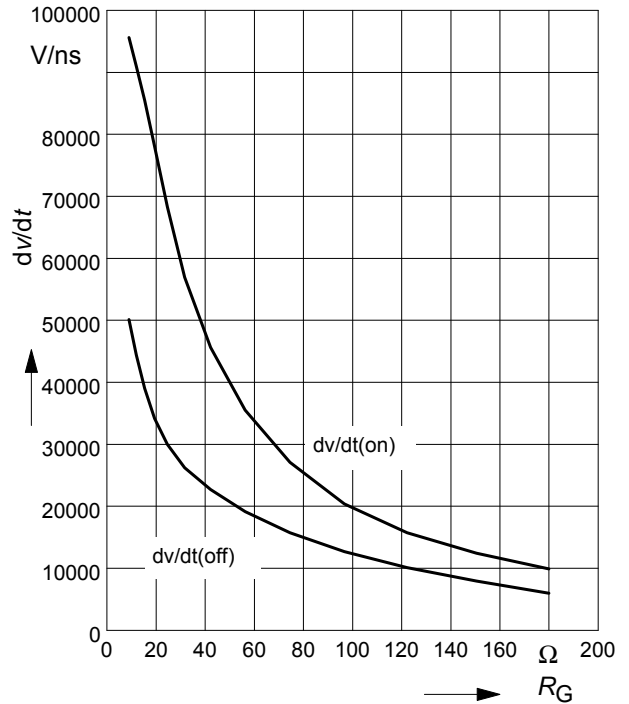
13 Typ. switching time

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



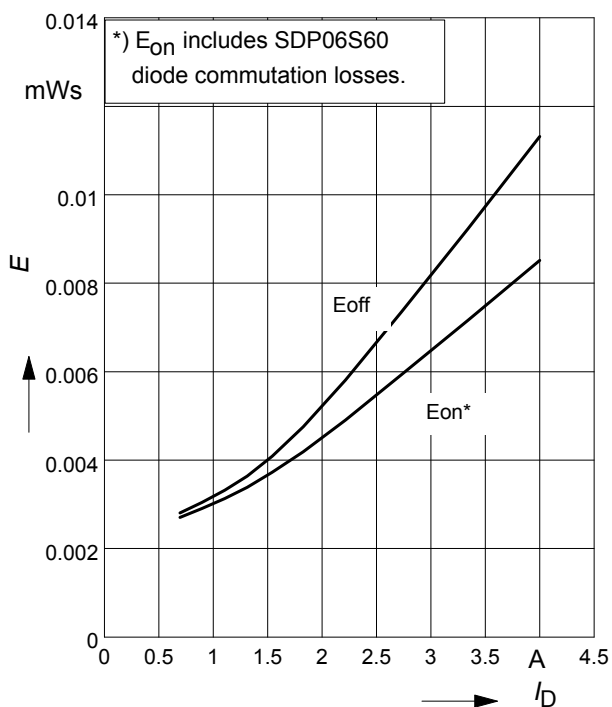
14 Typ. drain source voltage slope

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



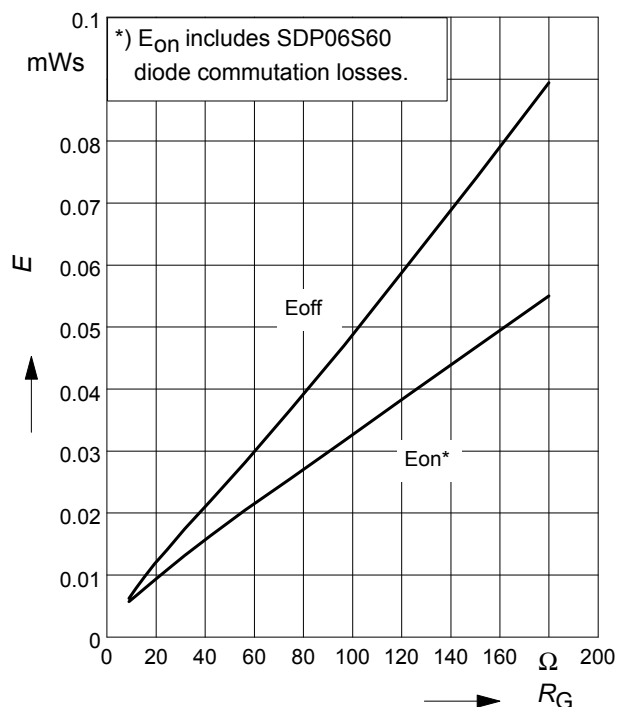
15 Typ. switching losses

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



16 Typ. switching losses

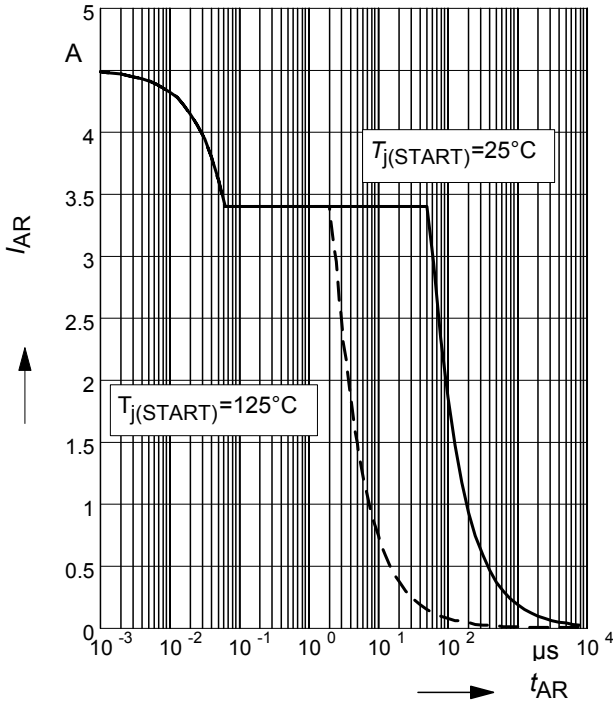
$E = f(R_G)$, inductive load, $T_j=125^\circ\text{C}$
 par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



17 Avalanche SOA

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

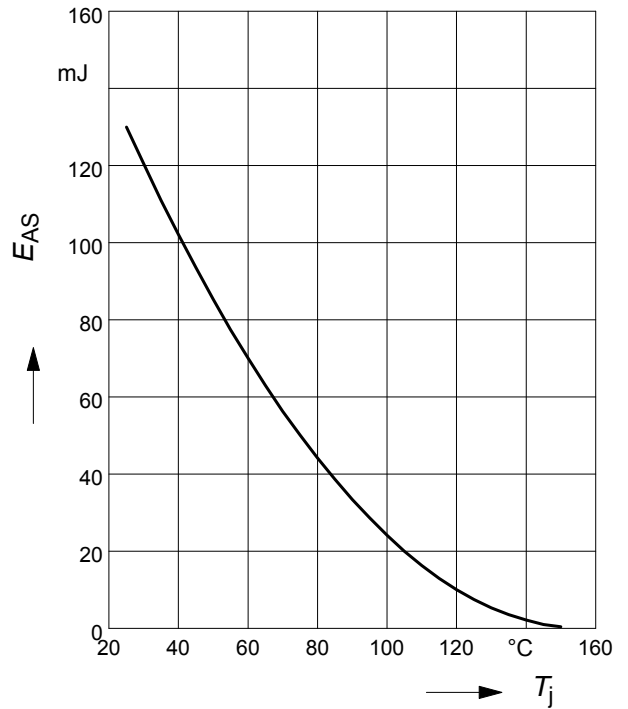
par.: $T_j \leq 150\text{ }^\circ\text{C}$



18 Avalanche energy

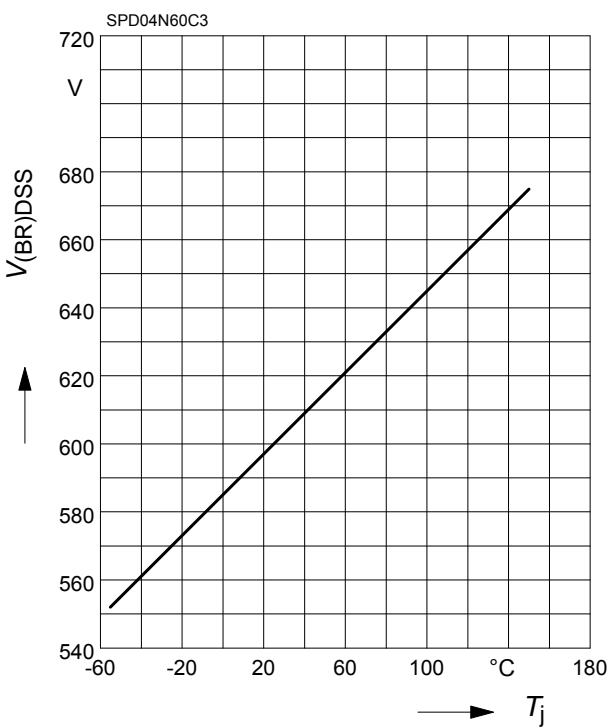
$E_{AS} = f(T_j)$

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



19 Drain-source breakdown voltage

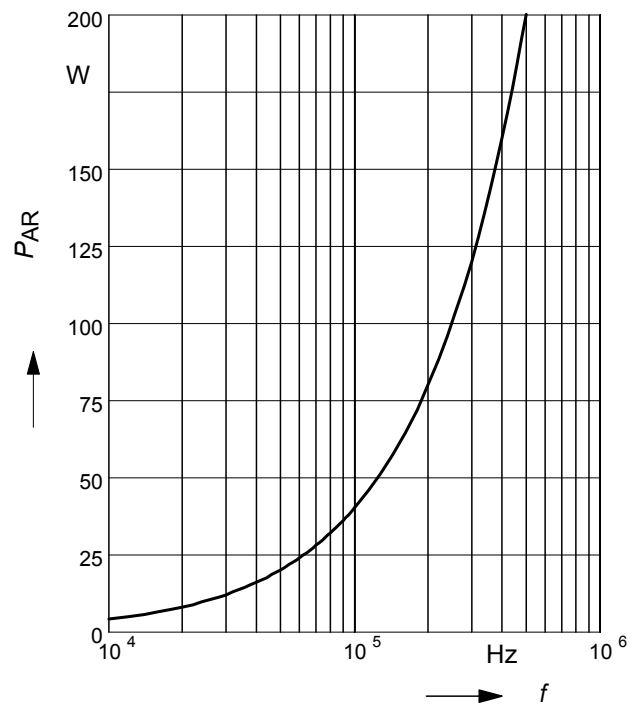
$V_{(BR)DSS} = f(T_j)$



20 Avalanche power losses

$P_{AR} = f(f)$

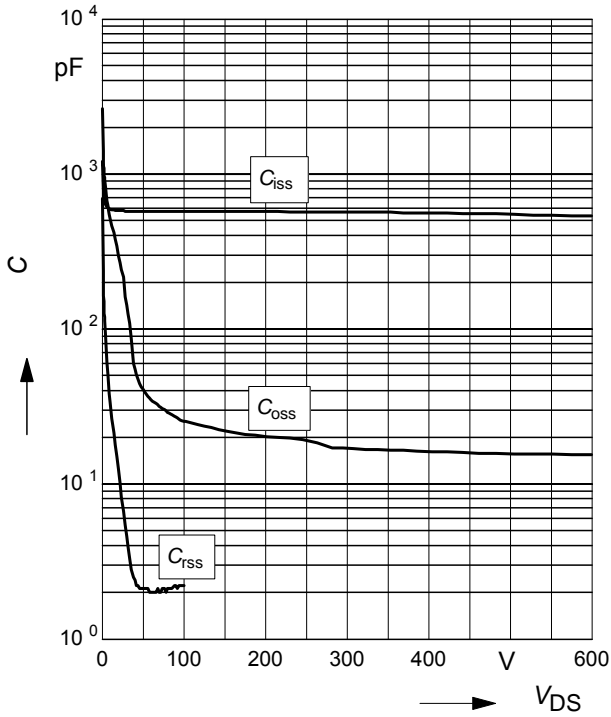
parameter: $E_{AR} = 0.4\text{ mJ}$



21 Typ. capacitances

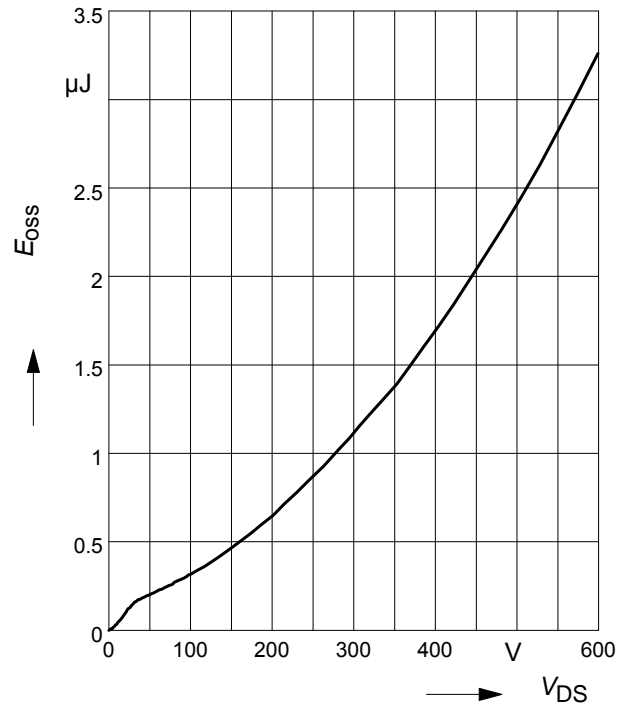
$C = f(V_{DS})$

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

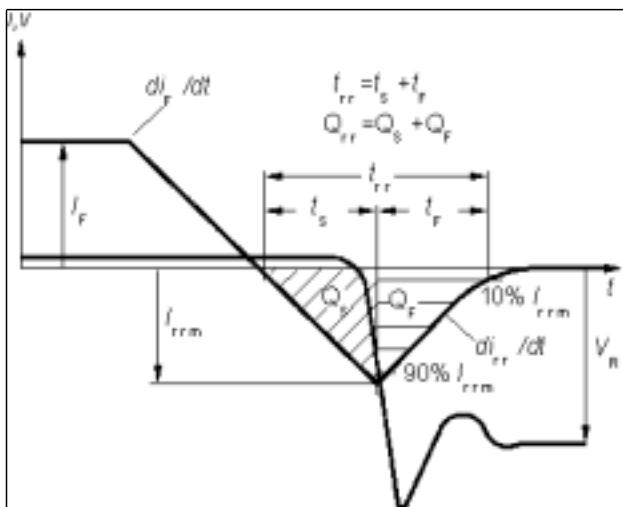


22 Typ. C_{OSS} stored energy

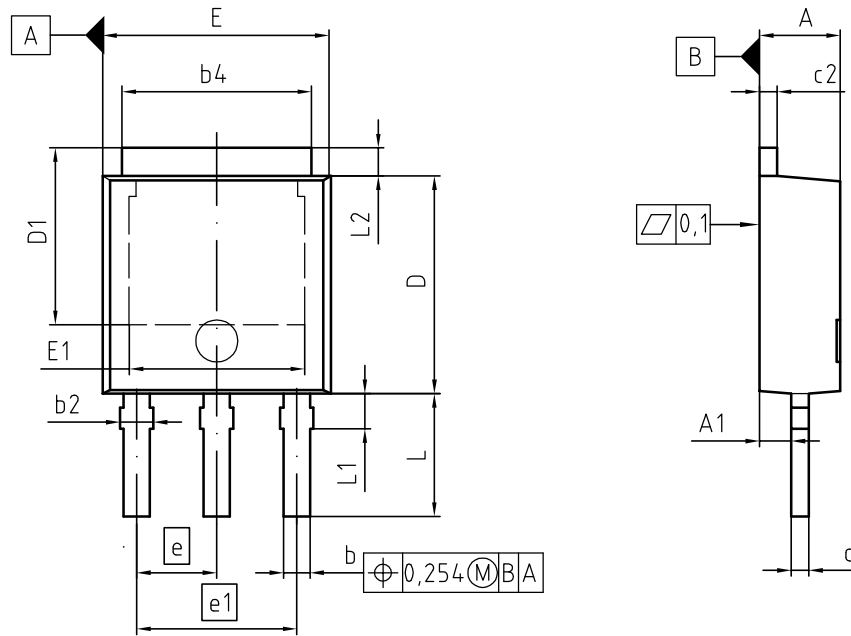
$E_{Oss}=f(V_{DS})$



Definition of diodes switching characteristics



PG-TO251-3-11



| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 2.18 | 2.39 | 0.086 | 0.094 |
| A1 | 0.80 | 1.14 | 0.031 | 0.045 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b2 | 0.65 | 1.15 | 0.026 | 0.045 |
| b4 | 4.95 | 5.50 | 0.195 | 0.217 |
| c | 0.46 | 0.58 | 0.018 | 0.023 |
| c2 | 0.46 | 0.89 | 0.018 | 0.035 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 5.04 | 5.44 | 0.198 | 0.214 |
| E | 6.35 | 6.73 | 0.250 | 0.265 |
| E1 | 4.90 | 5.10 | 0.193 | 0.201 |
| e | 2.29 | | 0.090 | |
| e1 | 4.57 | | 0.180 | |
| N | 3 | | 3 | |
| L | 3.40 | 3.60 | 0.134 | 0.142 |
| L1 | 0.90 | 1.10 | 0.035 | 0.043 |
| L2 | 0.90 | 1.10 | 0.035 | 0.043 |

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