

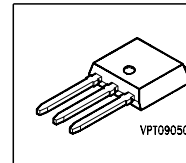
Cool MOS™ Power Transistor

Feature

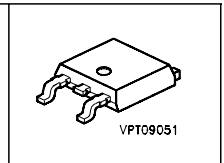
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance

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

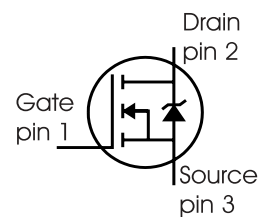
P-TO251



P-TO252



Type	Package	Ordering Code	Marking
SPD04N60C3	P-TO252	Q67040-S4412	04N60C3
SPU04N60C3	P-TO251	-	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	$^\circ\text{C}$

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, 1.6 mm (0.063 in.) from case for 10s	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	$V_{(BR)DSS}$	$V_{GS}=0V, I_D=0.25mA$	600	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0V, I_D=4.5A$	-	700	-	
Gate threshold voltage	$V_{GS(th)}$	$I_D=200\mu A, V_{GS}=V_{DS}$	2.1	3	3.9	
Zero gate voltage drain current	I_{DSS}	$V_{DS}=600V, V_{GS}=0V,$ $T_j=25^\circ\text{C},$ $T_j=150^\circ\text{C}$	-	0.5	1 50	μA
Gate-source leakage current	I_{GSS}	$V_{GS}=30V, V_{DS}=0V$	-	-	100	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS}=10V, I_D=2.8A,$ $T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	-	0.85	0.95 -	Ω
Gate input resistance	R_G	$f=1\text{MHz}, \text{open Drain}$	-	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

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

² Device 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} .

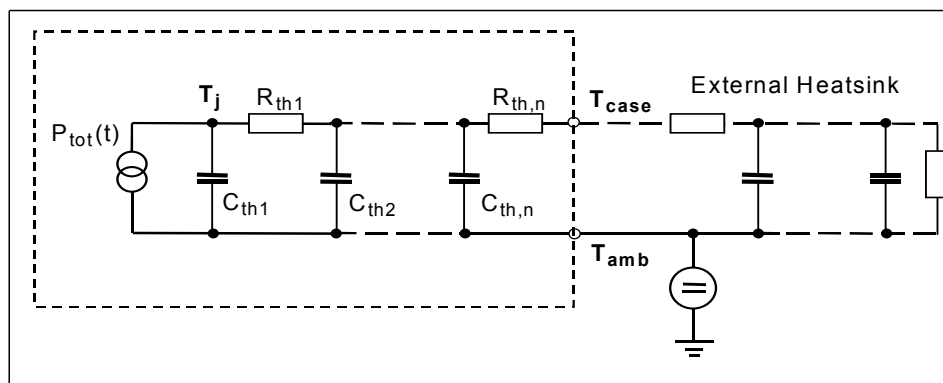
⁴ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

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

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

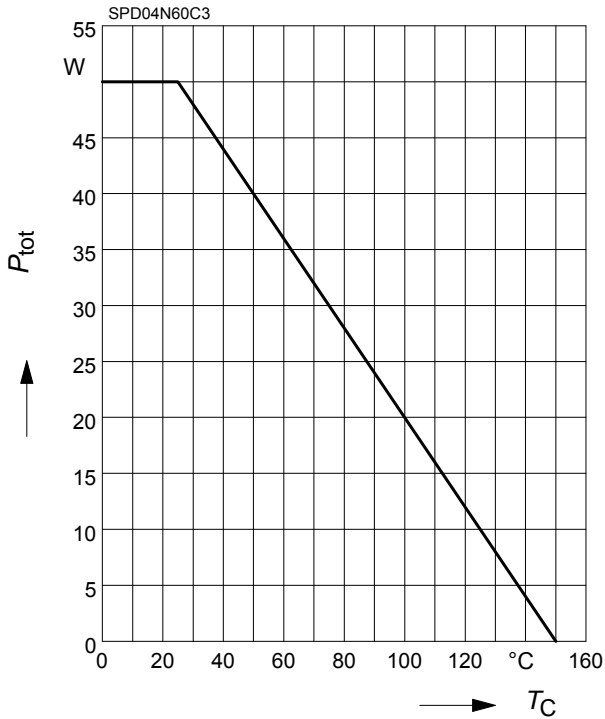
Typical Transient Thermal Characteristics

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

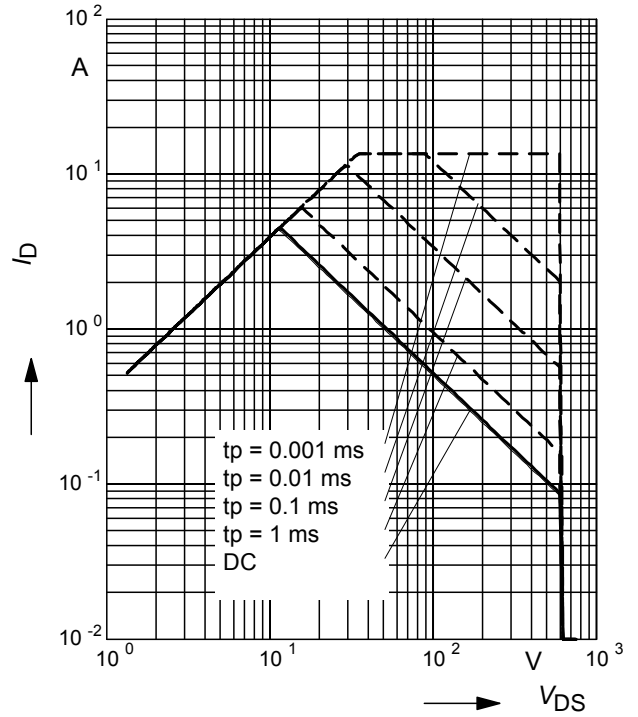
$$P_{tot} = f(T_C)$$



2 Safe operating area

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

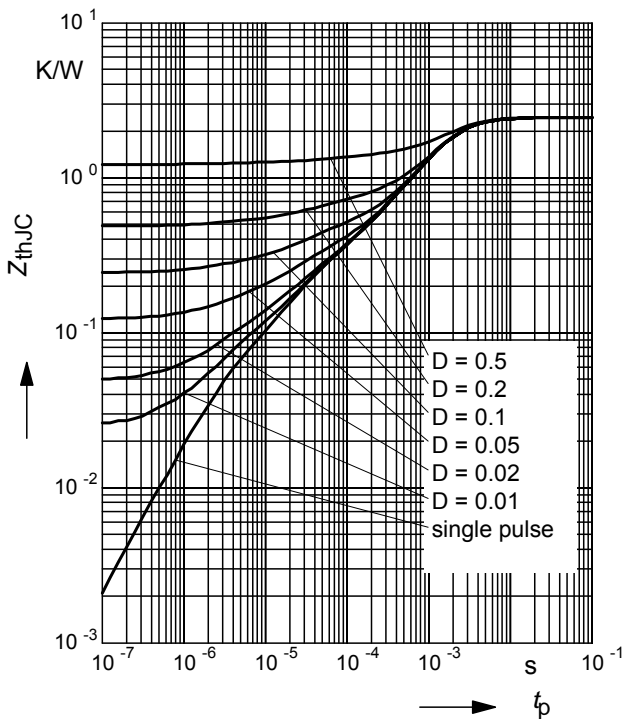
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



3 Transient thermal impedance

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

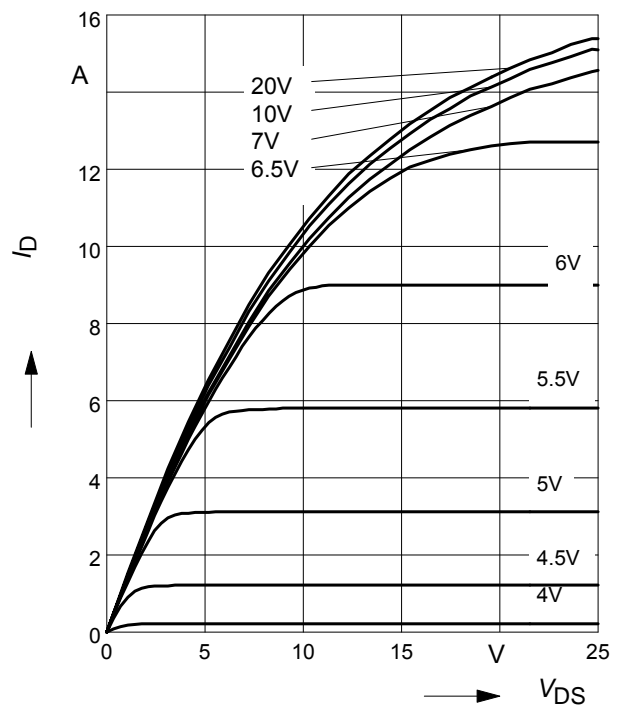
parameter: $D = t_p/T$



4 Typ. output characteristic

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

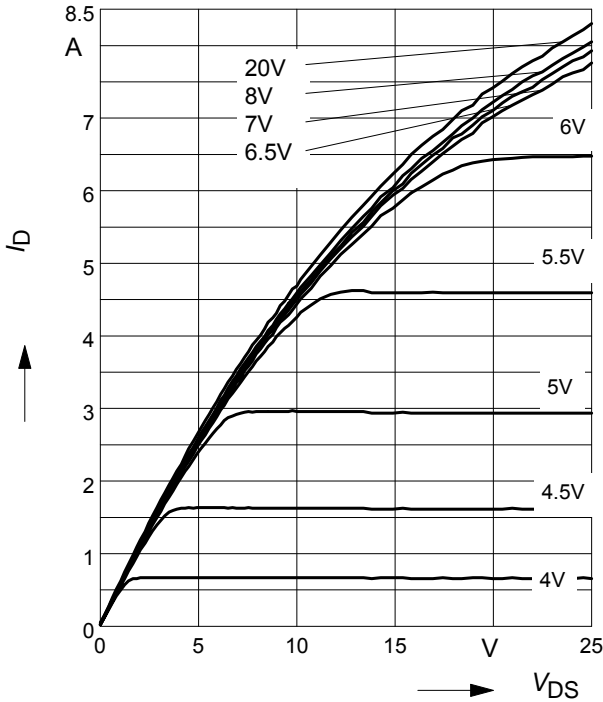
parameter: $t_p = 10 \mu\text{s}$, V_{GS}



5 Typ. output characteristic

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

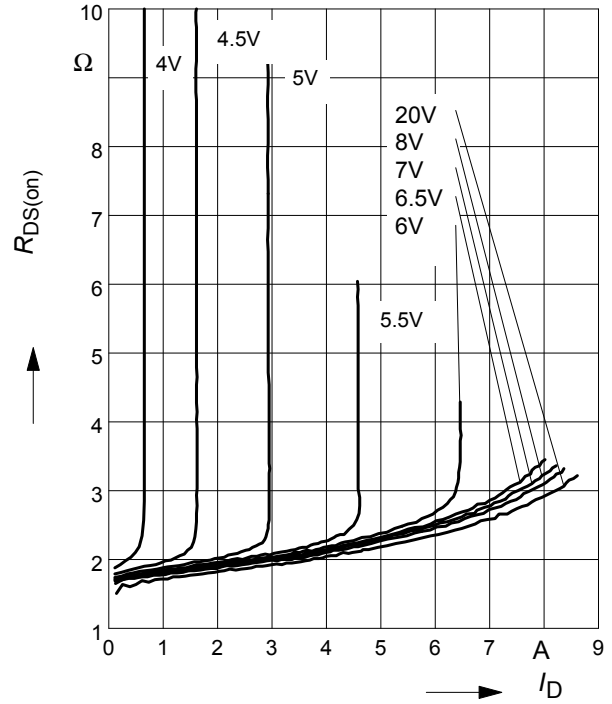
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



6 Typ. drain-source on resistance

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

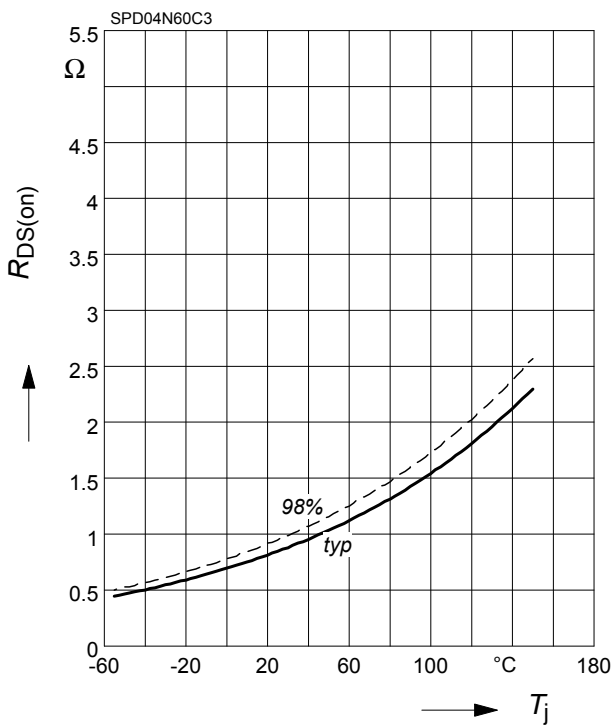
parameter: $T_j = 150^\circ\text{C}, V_{GS}$



7 Drain-source on-state resistance

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

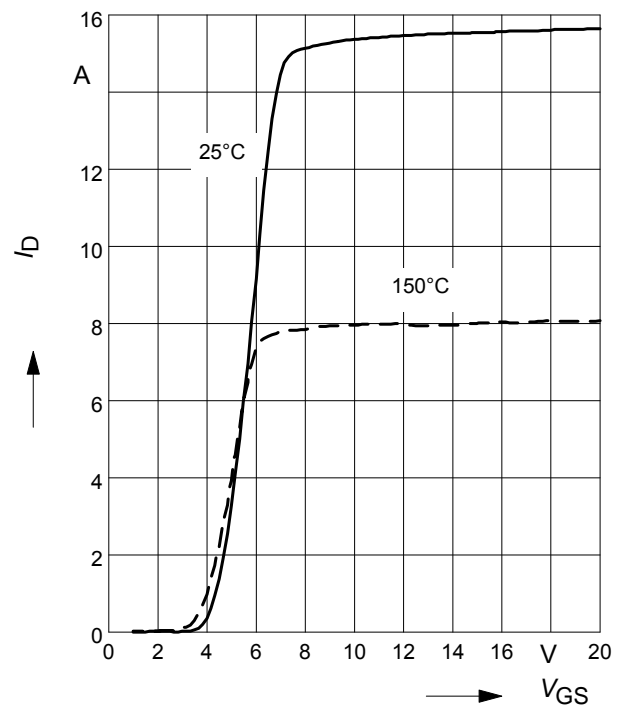
parameter: $I_D = 2.8 \text{ A}, V_{GS} = 10 \text{ V}$



8 Typ. transfer characteristics

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

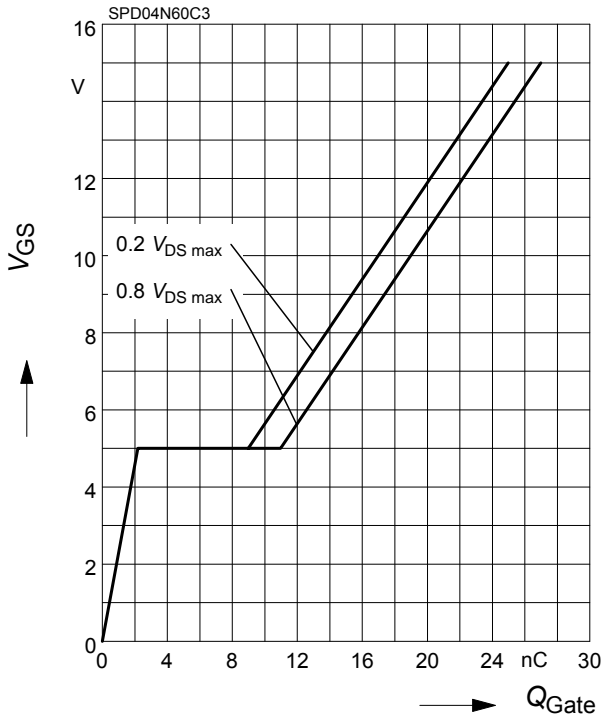
parameter: $t_p = 10 \mu\text{s}$



9 Typ. gate charge

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

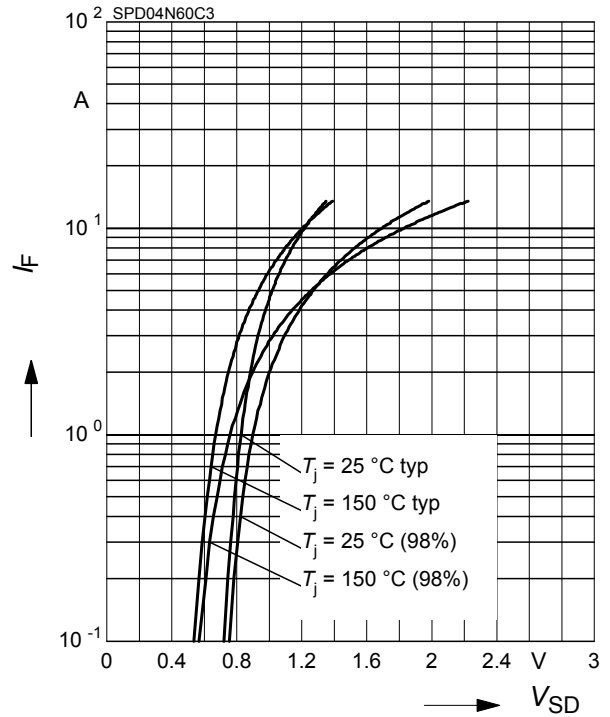
parameter: $I_D = 4.5$ A pulsed



10 Forward characteristics of body diode

$I_F = f(V_{SD})$

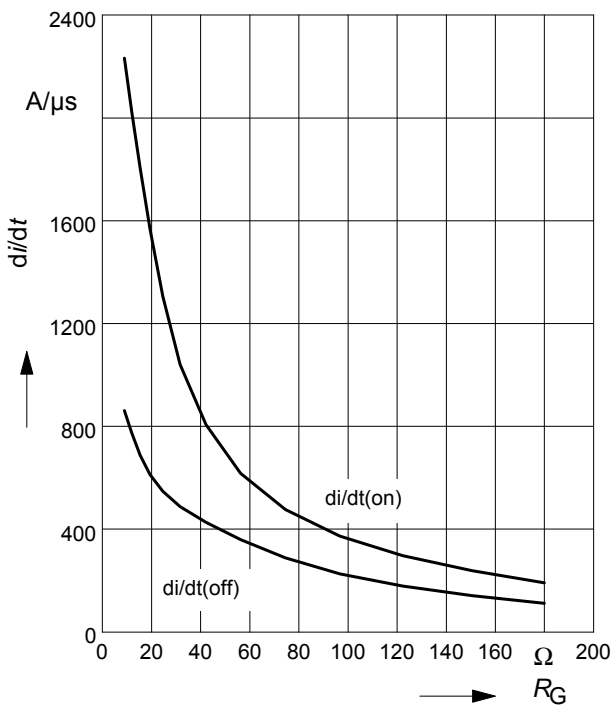
parameter: $T_j, t_p = 10$ μ s



11 Typ. drain current slope

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

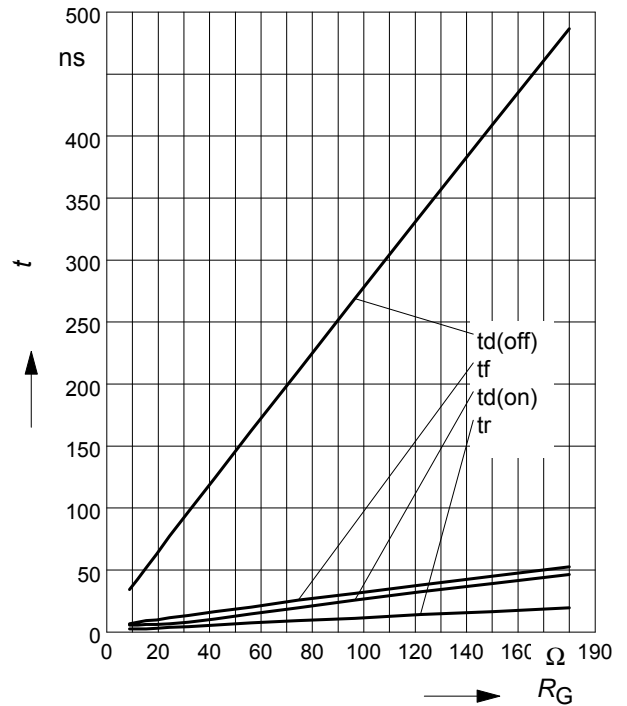
par.: $V_{DS} = 380$ V, $V_{GS} = 0/+13$ V, $I_D = 4.5$ A



12 Typ. switching time

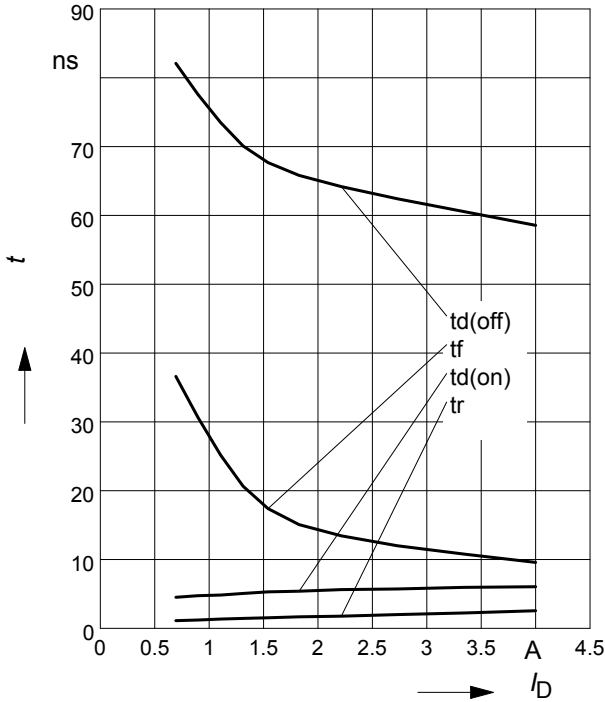
$t = f(R_G)$, inductive load, $T_j = 125$ °C

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



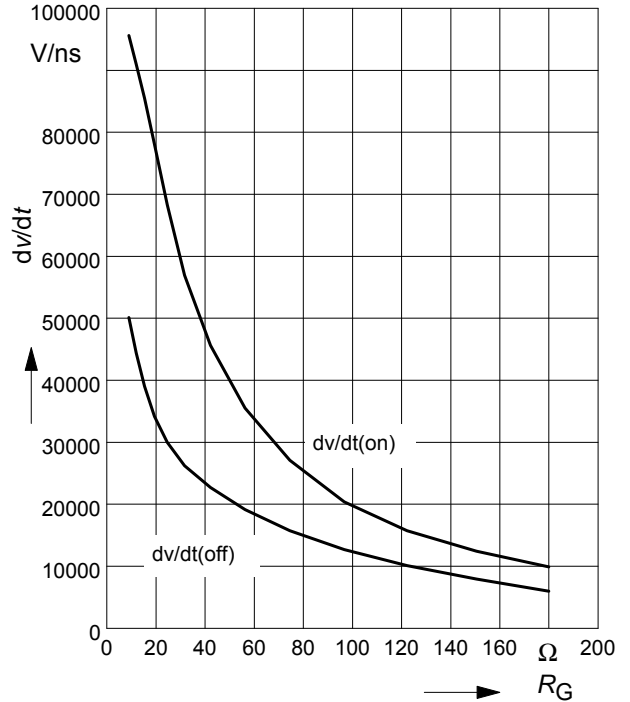
13 Typ. switching time

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



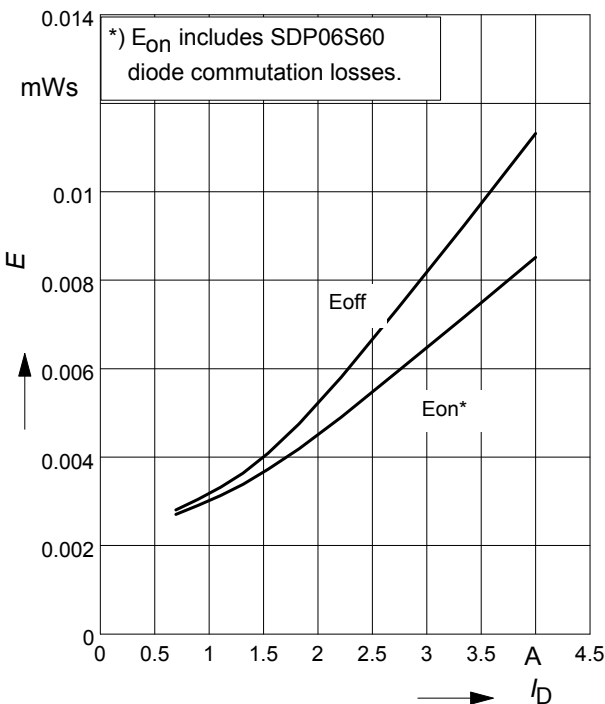
14 Typ. drain source voltage slope

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



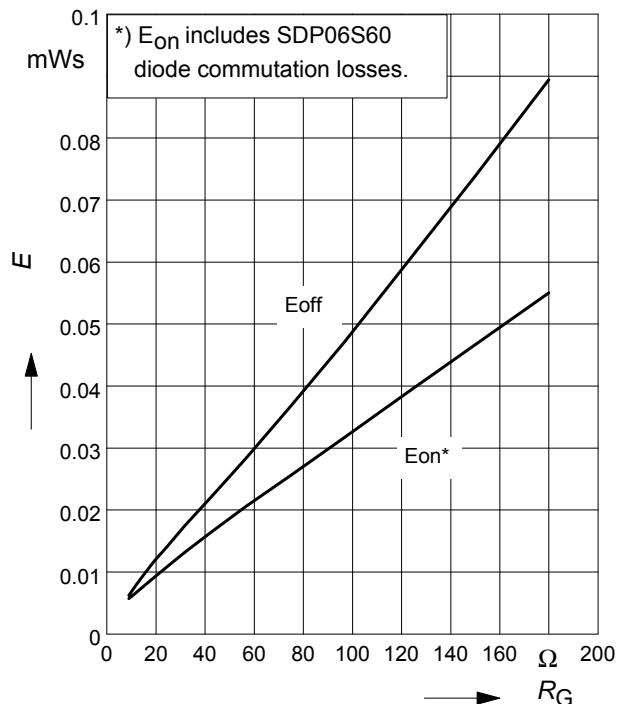
15 Typ. switching losses

$E = f(I_D)$, 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

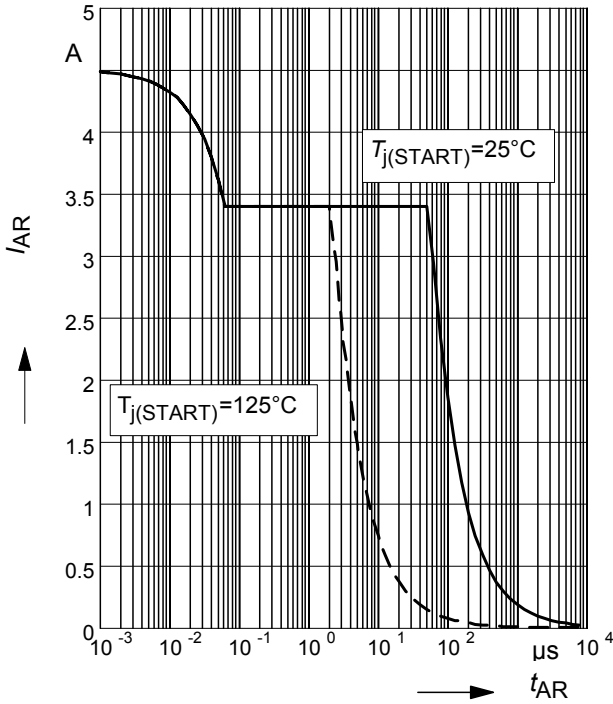
$E = f(R_G)$, inductive load, $T_j=125^\circ\text{C}$
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=4.5\text{A}$



17 Avalanche SOA

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

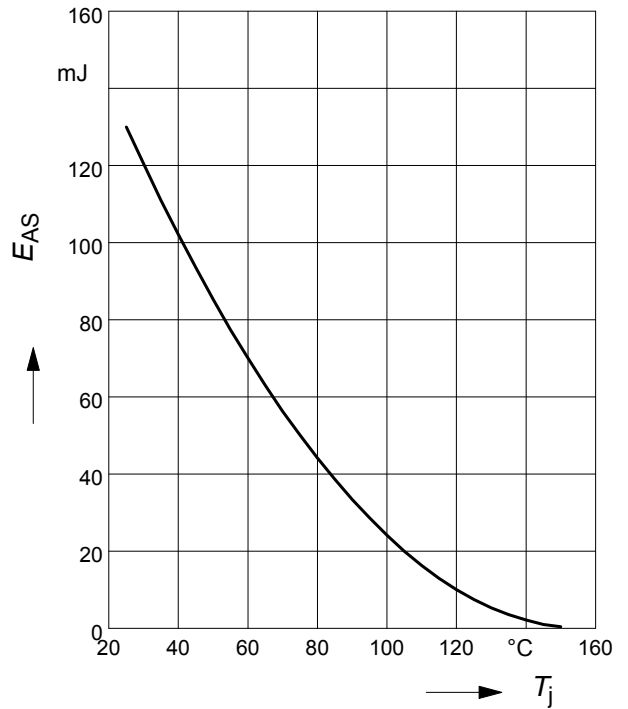
par.: $T_j \leq 150\text{ }^\circ\text{C}$



18 Avalanche energy

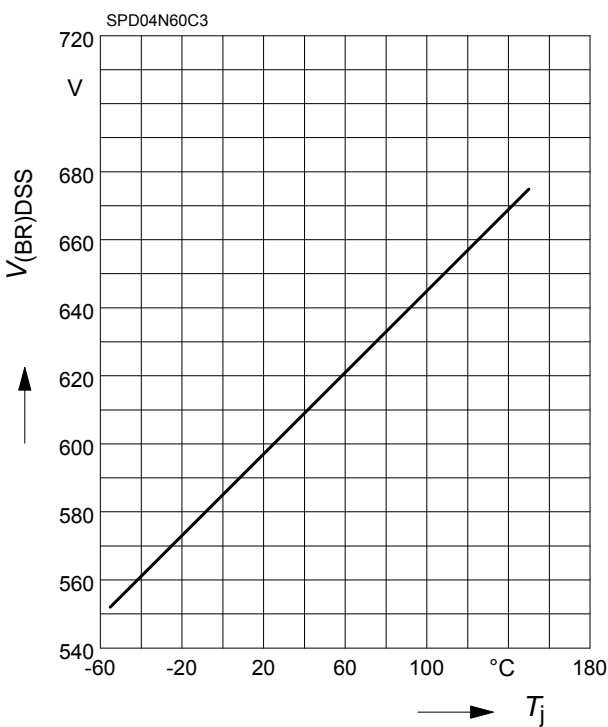
$E_{AS} = f(T_j)$

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



19 Drain-source breakdown voltage

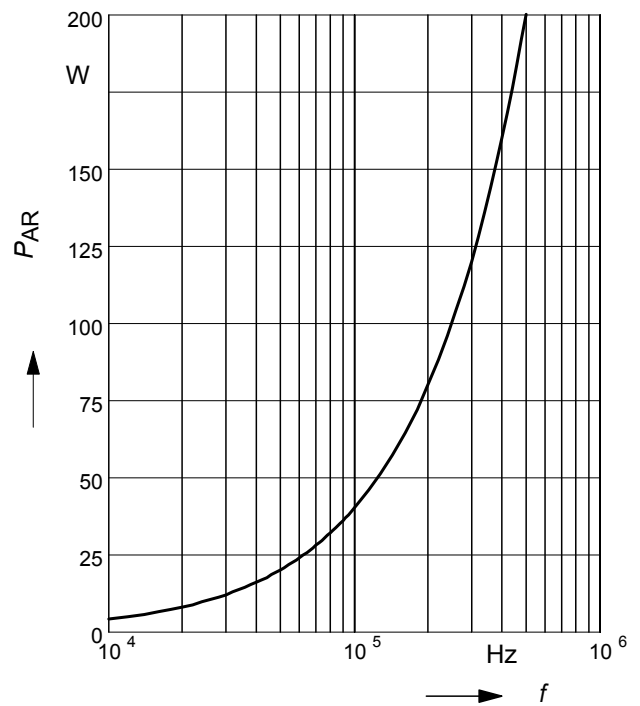
$V_{(BR)DSS} = f(T_j)$



20 Avalanche power losses

$P_{AR} = f(f)$

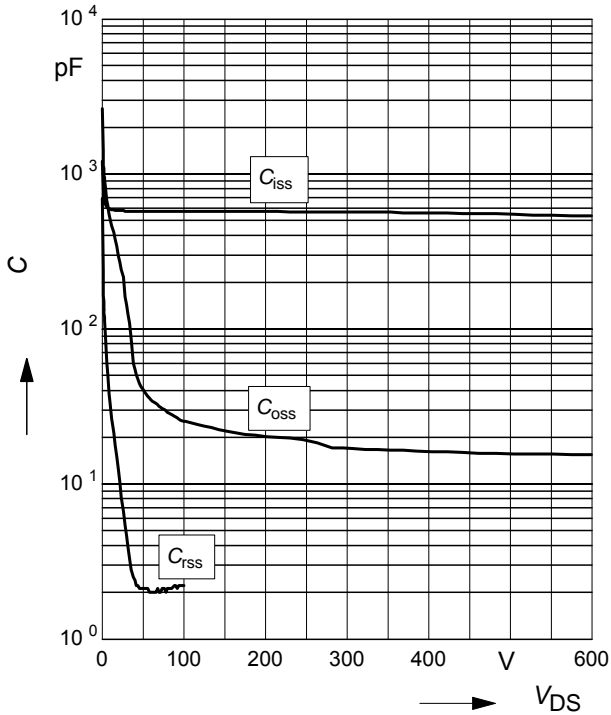
parameter: $E_{AR} = 0.4\text{ mJ}$



21 Typ. capacitances

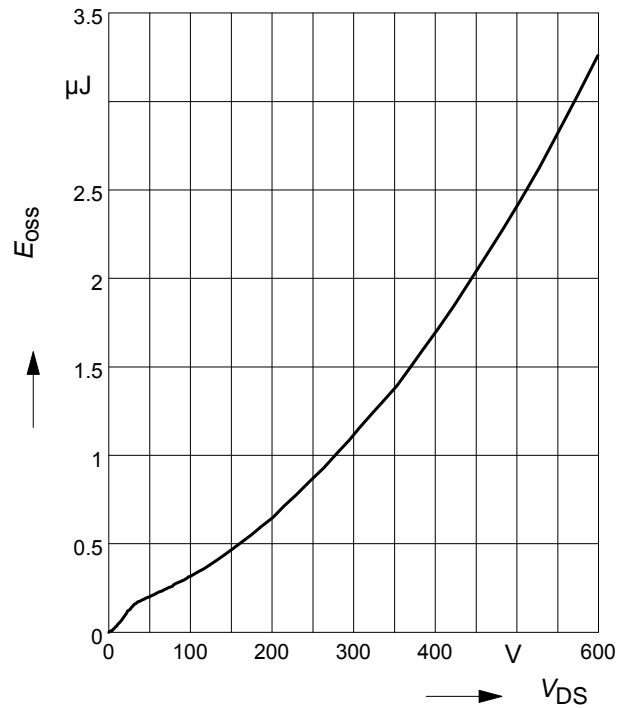
$$C = f(V_{DS})$$

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

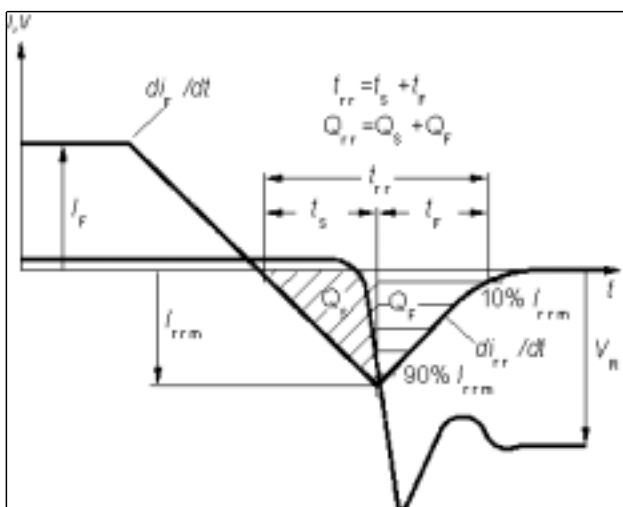


22 Typ. C_{oss} stored energy

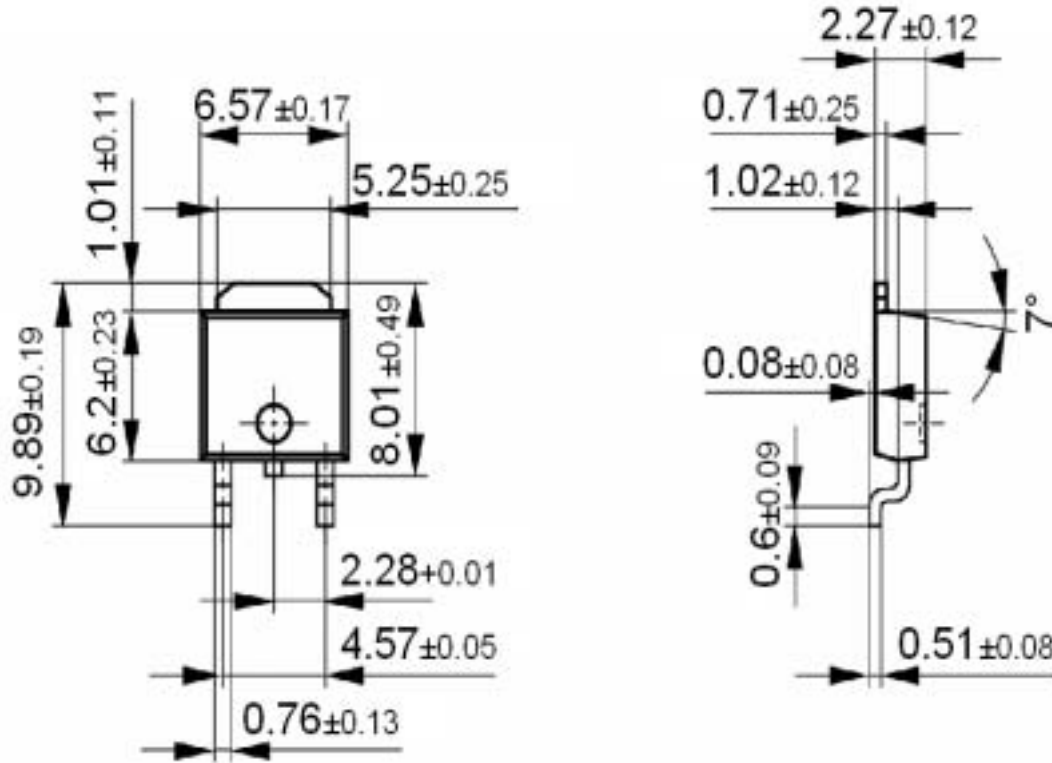
$$E_{Oss} = f(V_{DS})$$



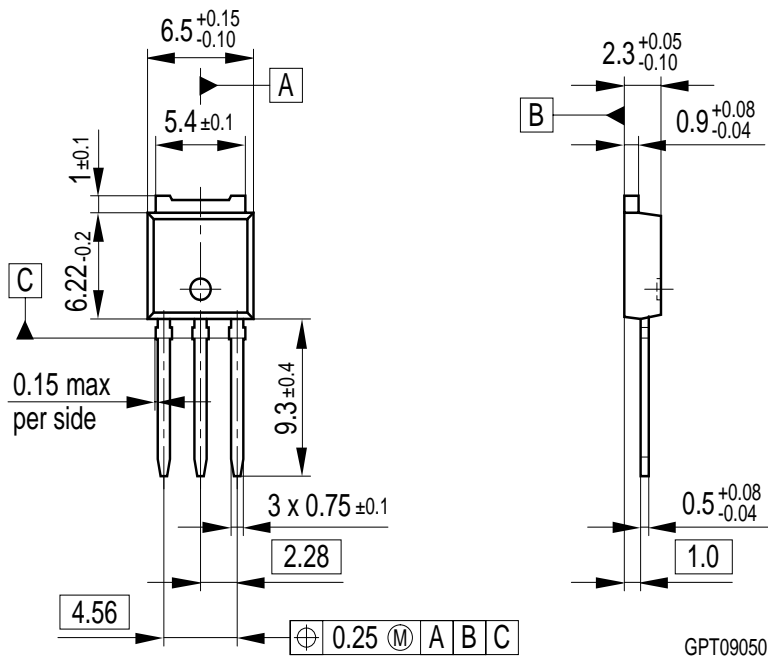
Definition of diodes switching characteristics



P-TO-252-3-1 (D-PAK)



P-TO-251-3-1 (I-PAK)



All metal surfaces tin plated, except area of cut.

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