

Cool MOS™ Power Transistor



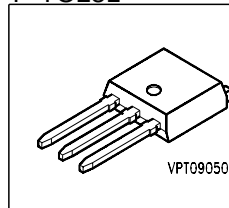
Feature

- New revolutionary high voltage technology
- Worldwide best $R_{DS(on)}$ in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- 150 °C operating temperature

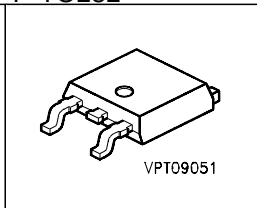
Product Summary

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

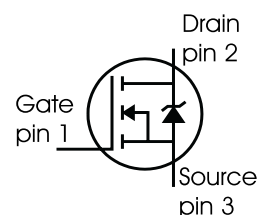
P-TO251



P-TO252



Type	Package	Ordering Code	Marking
SPD04N60C3	P-TO252	Q67040-S4412	04N60C3
SPU04N60C3	P-TO251	-	04N60C3



Maximum Ratings, at $T_j = 25\text{ °C}$, unless otherwise specified

Parameter	Symbol	Value	Unit
Continuous drain current	I_D	4.5	A
$T_C = 25\text{ °C}$			
$T_C = 100\text{ °C}$		2.8	
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	13.5	
Avalanche energy, single pulse	E_{AS}	130	mJ
$I_D = 2.3\text{ A}$, $V_{DD} = 50\text{ V}$			
Avalanche energy, repetitive t_{AR} limited by $T_{jmax}^{1)}$	E_{AR}	0.4	
$I_D = 4.5\text{ A}$, $V_{DD} = 50\text{ V}$			
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	4.5	A
Reverse diode dv/dt	dv/dt	6	V/ns
$I_S = 4.5\text{ A}$, $V_{DS} < V_{DD}$, $di/dt = 100\text{ A}/\mu\text{s}$, $T_{jmax} = 150\text{ °C}$			
Gate source voltage static	V_{GS}	± 20	V
Gate source voltage dynamic	V_{GS}	± 30	
Power dissipation, $T_C = 25\text{ °C}$	P_{tot}	50	W
Operating and storage temperature	T_j, T_{stg}	-55... +150	°C

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Characteristics					
Thermal resistance, junction - case	R_{thJC}	-	-	2.5	K/W
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
SMD version, device on PCB:	R_{thJA}				
@ min. footprint		-	-	62	
@ 6 cm ² cooling area 2)		-	35	-	
Linear derating factor		-	-	0.4	W/K
Soldering temperature, 1.6 mm (0.063 in.) from case for 10s	T_{sold}	-	-	260	°C

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

Static Characteristics

Drain-source breakdown voltage $V_{GS}=0V, I_D=0.25mA$	$V_{(BR)DSS}$	600	-	-	V
Drain-source avalanche breakdown voltage $V_{GS}=0V, I_D=4.5A$	$V_{(BR)DS}$	-	700	-	
Gate threshold voltage, $V_{GS} = V_{DS}$ $I_D = 200\text{ }\mu A$	$V_{GS(th)}$	2.1	3	3.9	
Zero gate voltage drain current $V_{DS} = 600V, V_{GS} = 0V, T_j = 25\text{ °C}$ $V_{DS} = 600V, V_{GS} = 0V, T_j = 150\text{ °C}$	I_{DSS}	- -	0.5 -	1 50	μA
Gate-source leakage current $V_{GS}=20V, V_{DS}=0V$	I_{GSS}	-	-	100	
Drain-source on-state resistance $V_{GS}=10V, I_D=2.8A, T_j=25\text{ °C}$ $V_{GS}=10V, I_D=2.8A, T_j=150\text{ °C}$	$R_{DS(on)}$	- -	0.85 2.35	0.95 2.62	Ω
Gate input resistance $f = 1\text{ MHz, open drain}$	R_G	-	0.95	-	

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

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.

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
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}	$V_{GS} = 0V$, $V_{DS} = 25V$, $f = 1MHz$	-	580	-	pF
Output capacitance	C_{oss}		-	220	-	
Reverse transfer capacitance	C_{rss}		-	7	-	
Effective output capacitance, ¹⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 0V$ to 480V	-	20	-	pF
Effective output capacitance, ²⁾ 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}	$V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$	-	2.2	-	nC
Gate to drain charge	Q_{gd}		-	8.8	-	
Gate charge total	Q_g	$V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$, $V_{GS} = 0$ to 10V	-	19	25	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480\text{V}$, $I_D = 4.5\text{A}$	-	5	-	V

¹⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

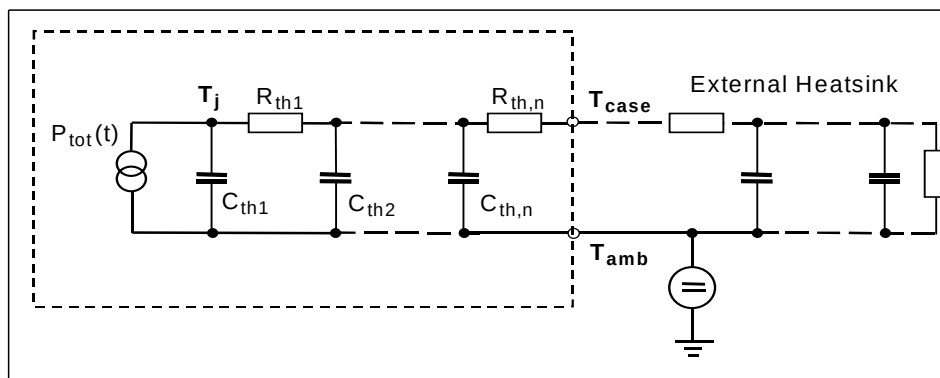
²⁾ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
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}	$V_R=480\text{V}, I_F=I_S,$ $di_F/dt=100\text{A}/\mu\text{s}$	-	300	500	ns
Reverse recovery charge	Q_{rr}		-	2.6	-	μC
Peak reverse recovery current	I_{rrm}		-	18	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt		-	-	900	$\text{A}/\mu\text{s}$

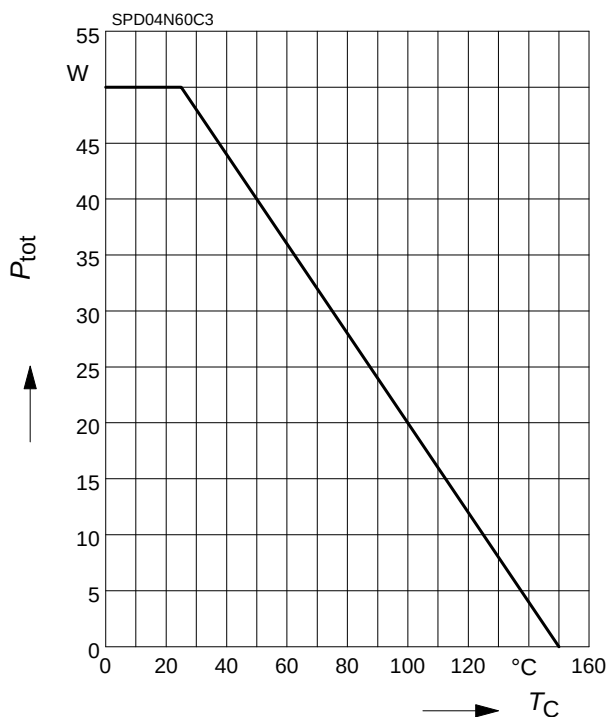
Transient Thermal Characteristics

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
R_{th1}	0.039	K/W	C_{th1}	0.00008293	Ws/K
R_{th2}	0.083		C_{th2}	0.000282	
R_{th3}	0.133		C_{th3}	0.0004859	
R_{th4}	0.275		C_{th4}	0.0011	
R_{th5}	0.278		C_{th5}	0.00535	
R_{th6}	0.093		C_{th6}	0.054	



1 Power dissipation

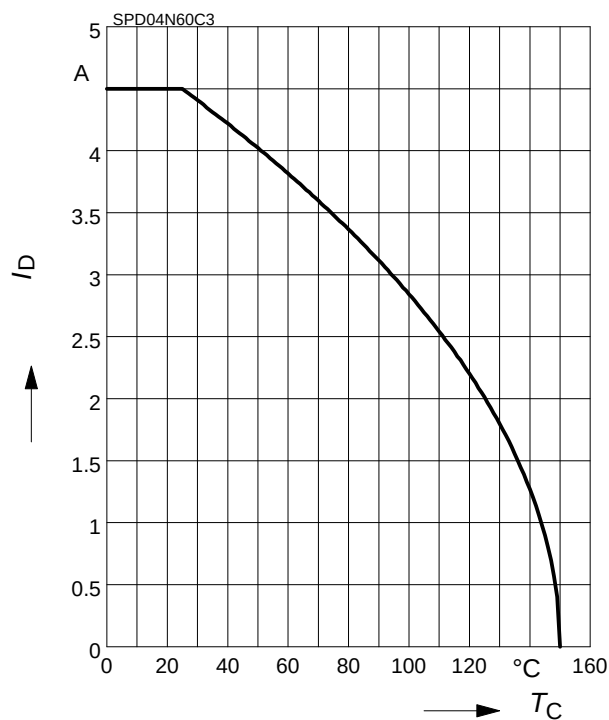
$$P_{\text{tot}} = f(T_C)$$



2 Drain current

$$I_D = f(T_C)$$

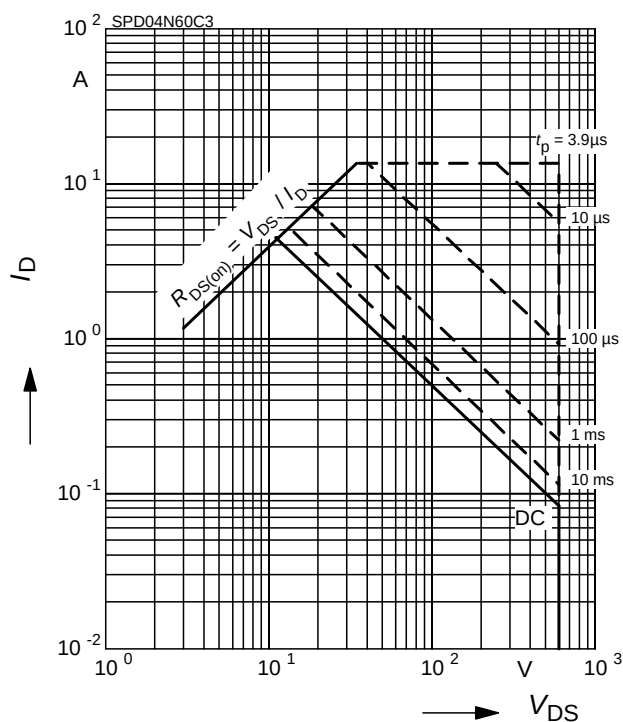
parameter: $V_{GS} \geq 10$ V



3 Safe operating area

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

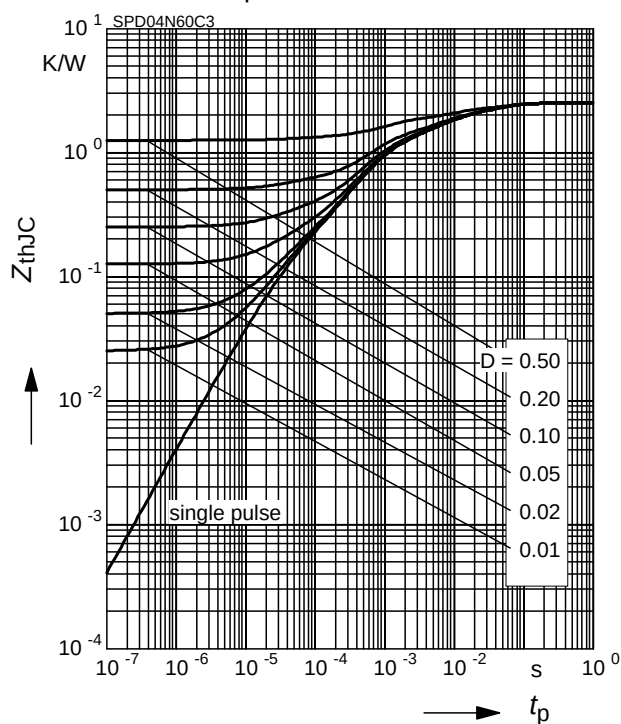
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



4 Transient thermal impedance

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

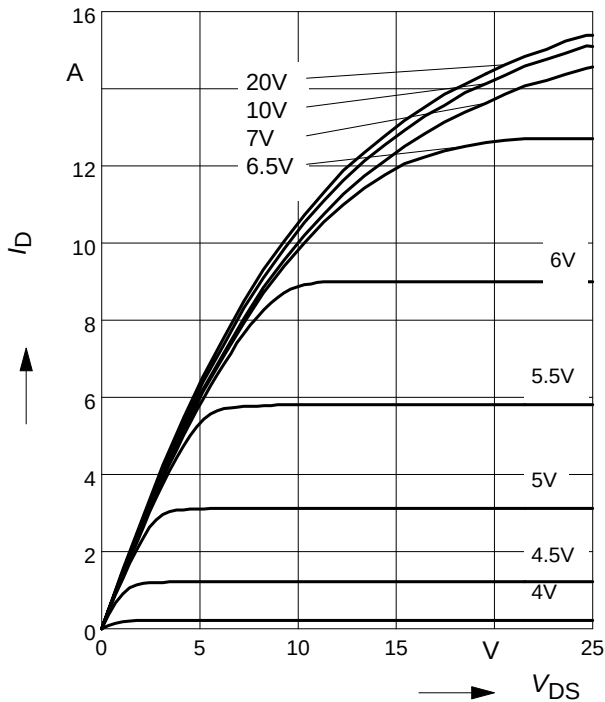
parameter: $D = t_p/T$



5 Typ. output characteristic

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

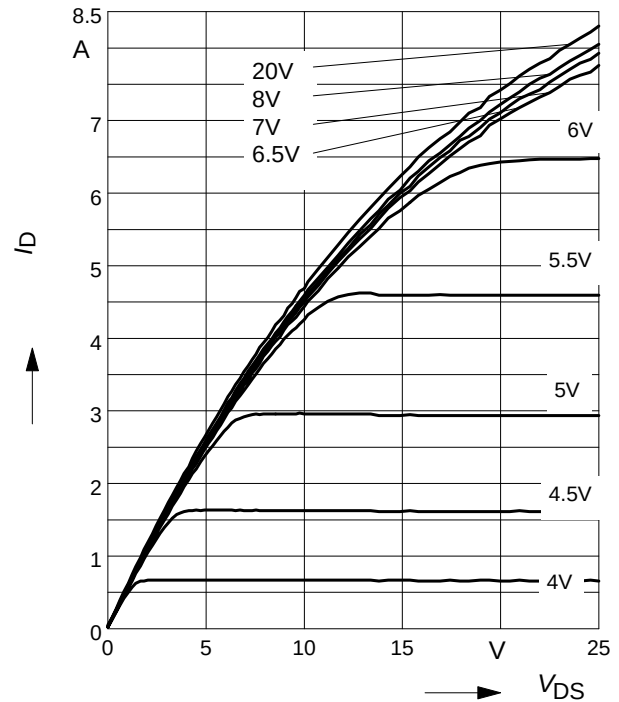
parameter: $t_p = 10 \mu\text{s}$, V_{GS}



6 Typ. output characteristic

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

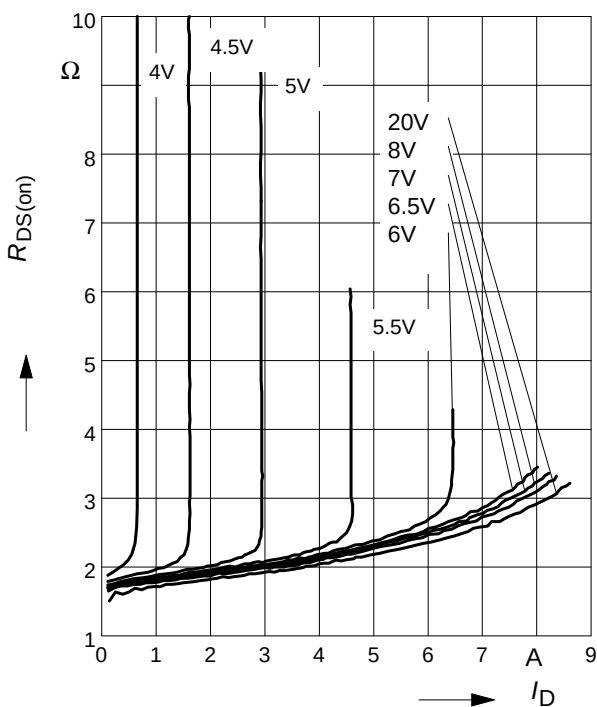
parameter: $t_p = 10 \mu\text{s}$, V_{GS}



7 Typ. drain-source on resistance

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

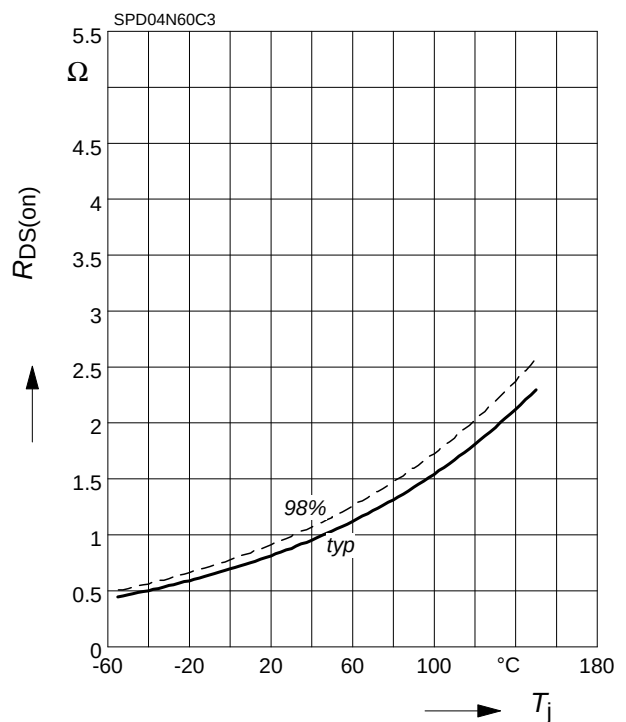
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



8 Drain-source on-state resistance

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

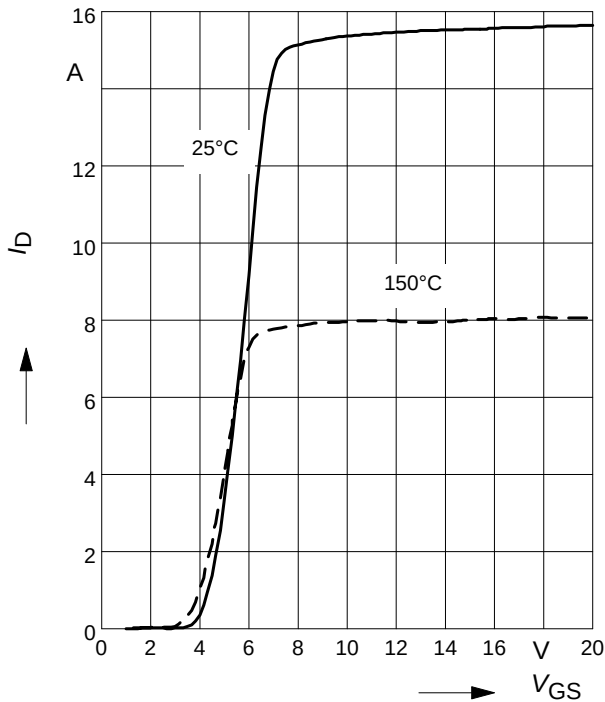
parameter: $I_D = 2.8 \text{ A}$, $V_{GS} = 10 \text{ V}$



9 Typ. transfer characteristics

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

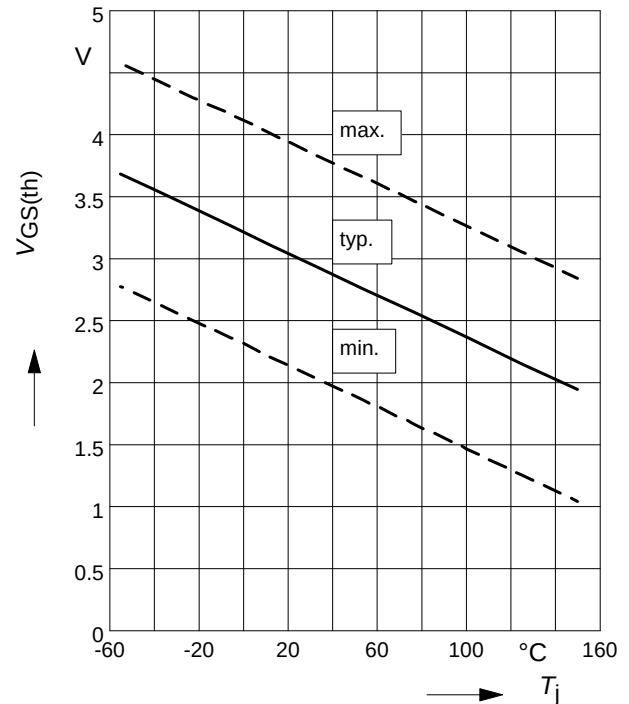
parameter: $t_p = 10 \mu s$



10 Gate threshold voltage

$$V_{GS(th)} = f(T_j)$$

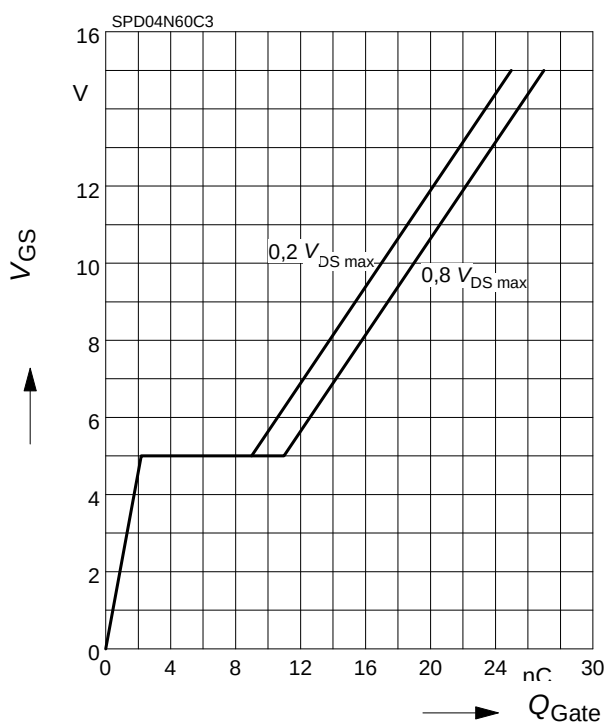
parameter: $V_{GS} = V_{DS}$, $I_D = 200 \mu A$



11 Typ. gate charge

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

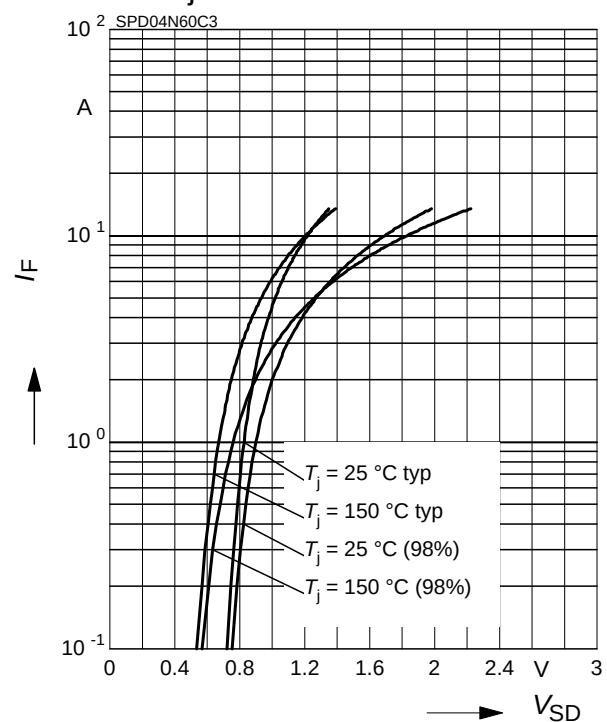
parameter: $I_D = 4.5 A$ pulsed



12 Forward characteristics of body diode

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

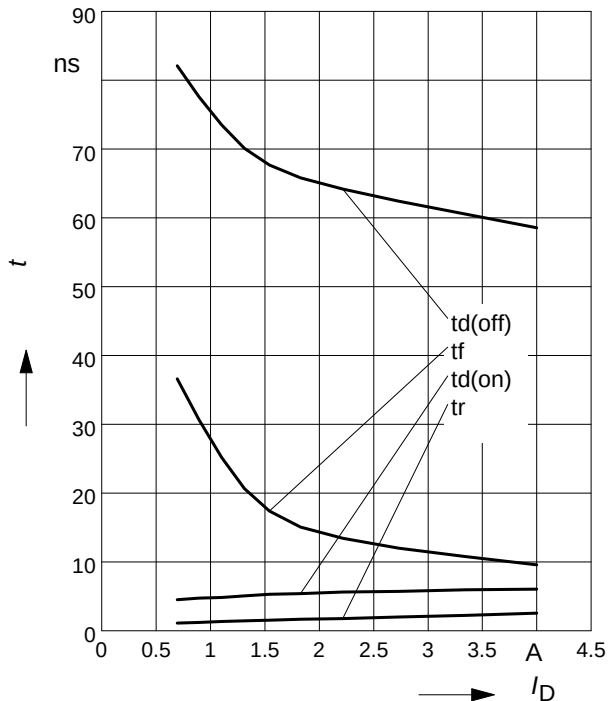
parameter: T_j , $t_p = 10 \mu s$



18 Typ. switching time

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

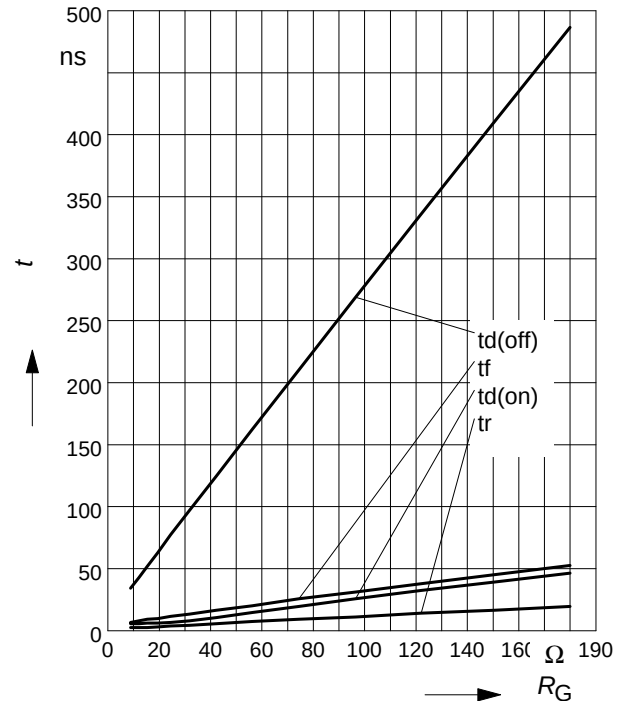
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $R_G = 18\Omega$



13 Typ. switching time

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

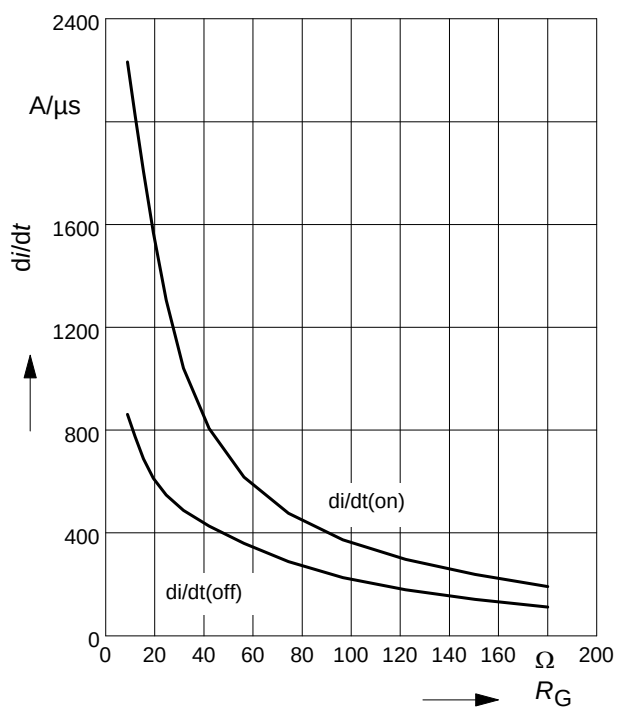
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{ A}$



14 Typ. drain current slope

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

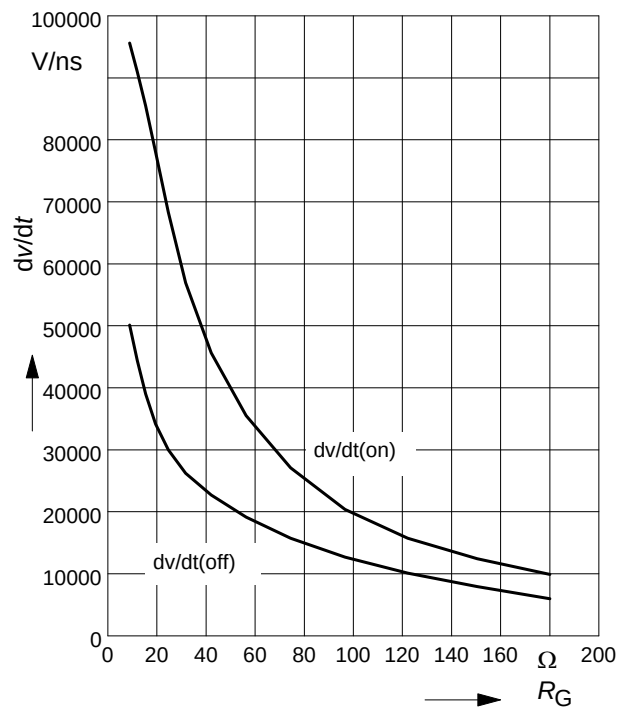
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



15 Typ. drain source voltage slope

$dv/dt = f(R_G)$, inductive load, $T_j = 125^\circ\text{C}$

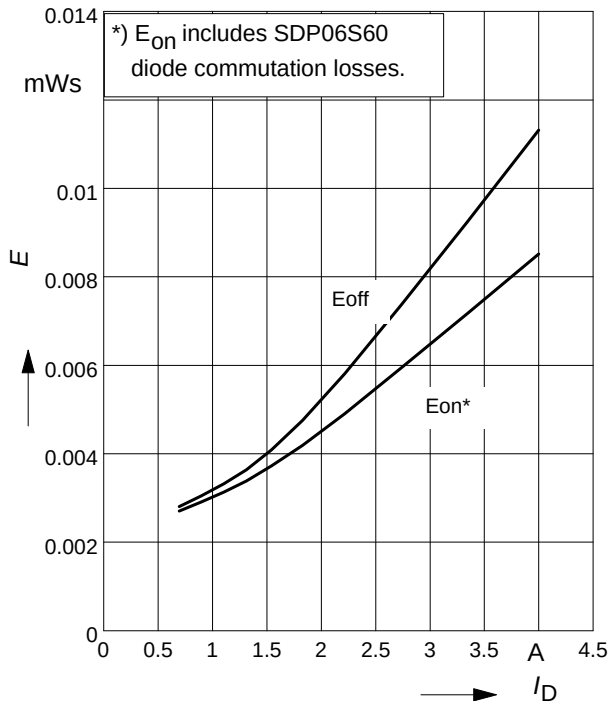
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



16 Typ. switching losses

$E = f(I_D)$, inductive load, $T_j = 125^\circ\text{C}$

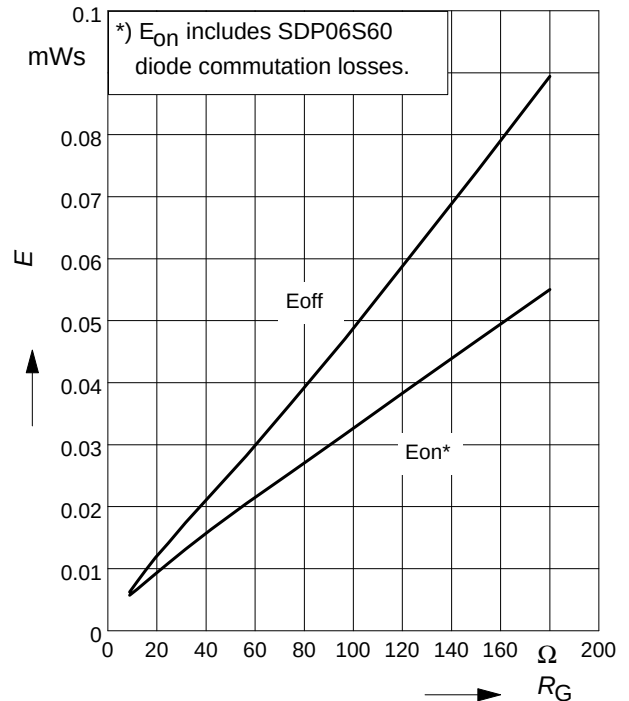
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $R_G = 18\Omega$



17 Typ. switching losses

$E = f(R_G)$, inductive load, $T_j = 125^\circ\text{C}$

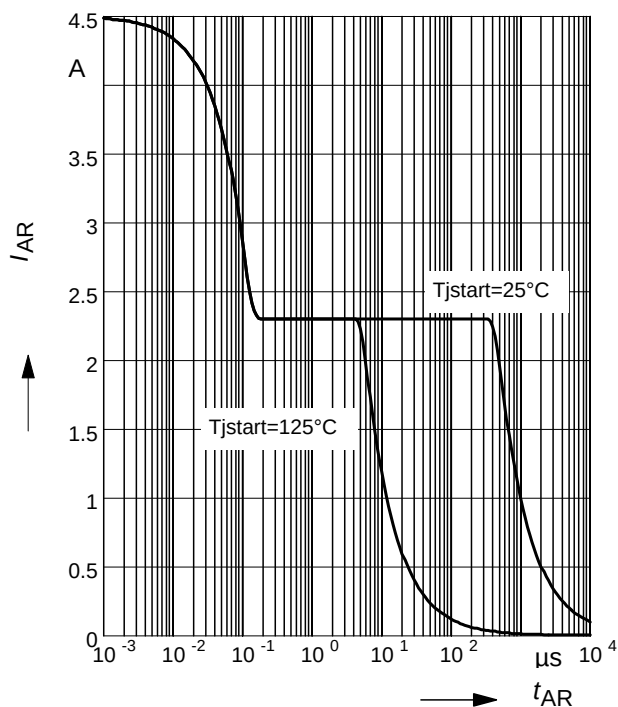
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



18 Avalanche SOA

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

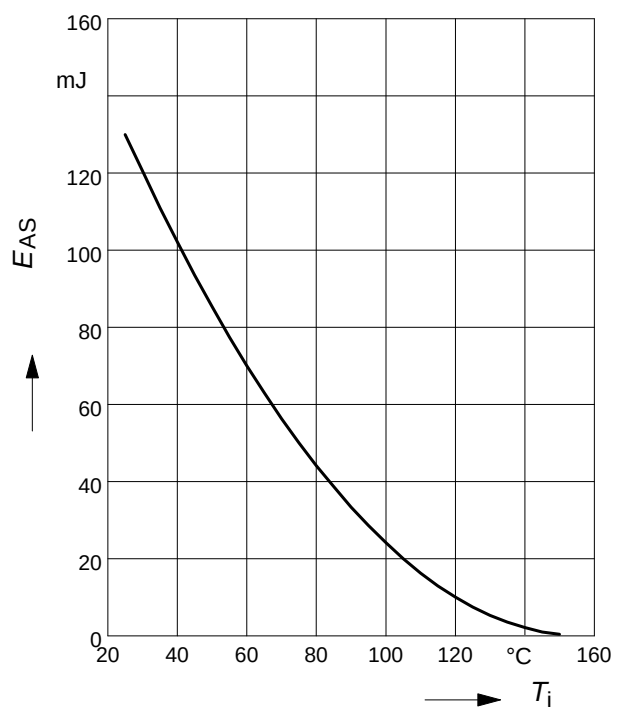
par.: $T_j \leq 150^\circ\text{C}$



19 Avalanche energy

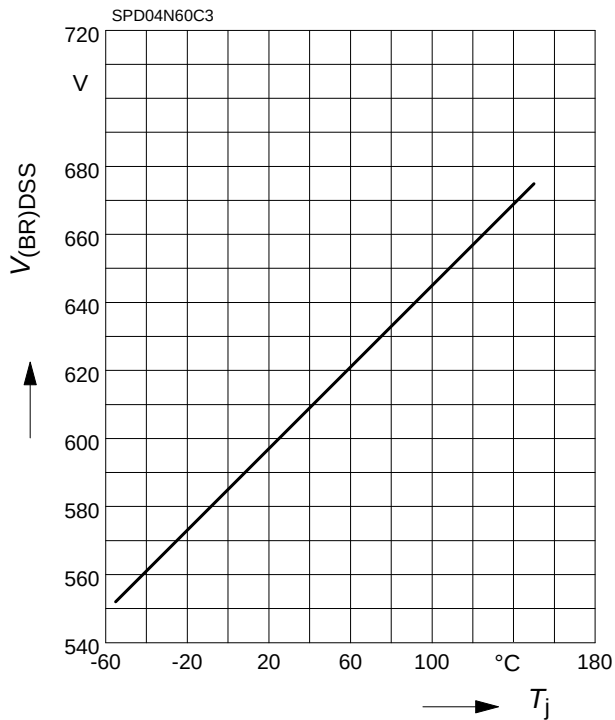
$E_{AS} = f(T_j)$

par.: $I_D = 2.3\text{A}$, $V_{DD} = 50\text{V}$



20 Drain-source breakdown voltage

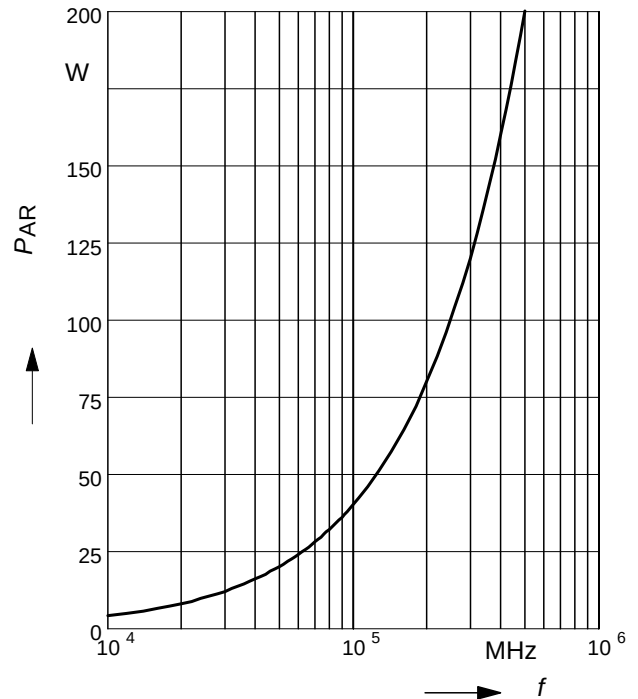
$$V_{(BR)DSS} = f(T_j)$$



21 Avalanche power losses

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

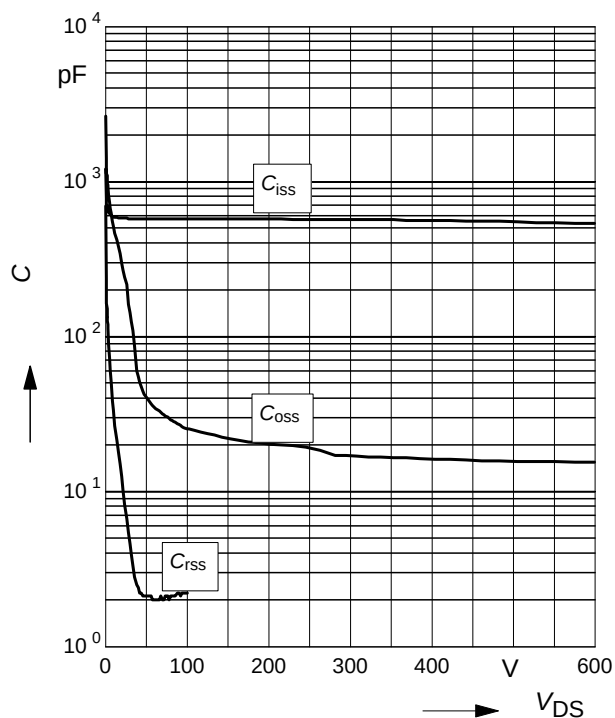
parameter: $E_{AR}=0.4\text{mJ}$



22 Typ. capacitances

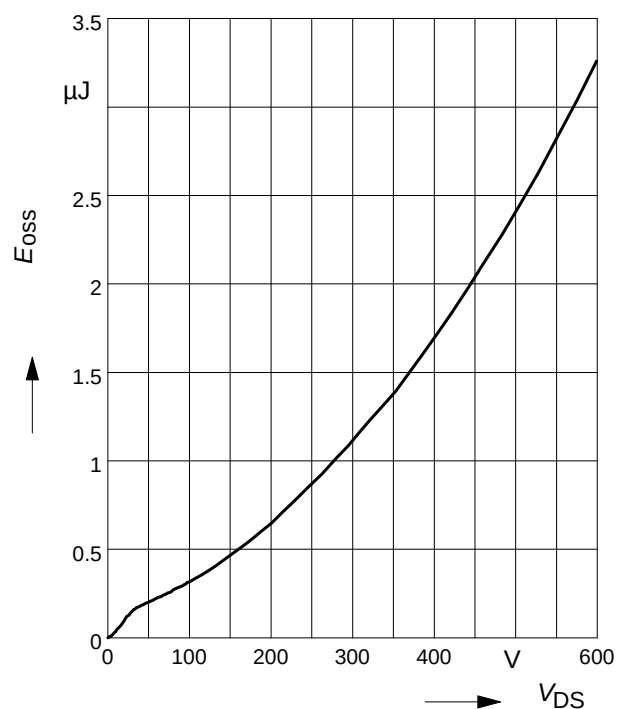
$$C = f(V_{DS})$$

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

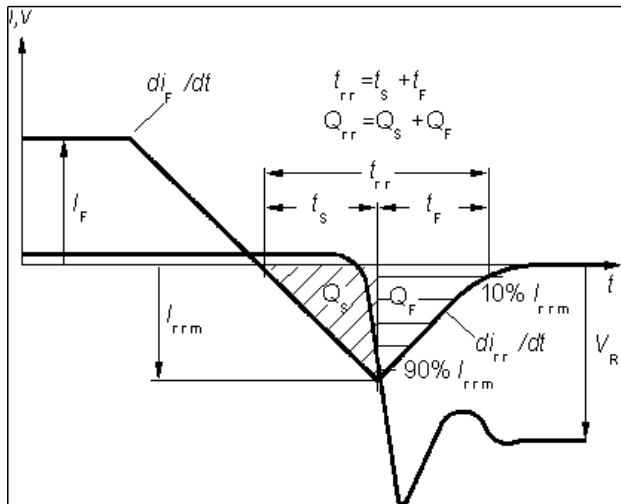


23 Typ. C_{oss} stored energy

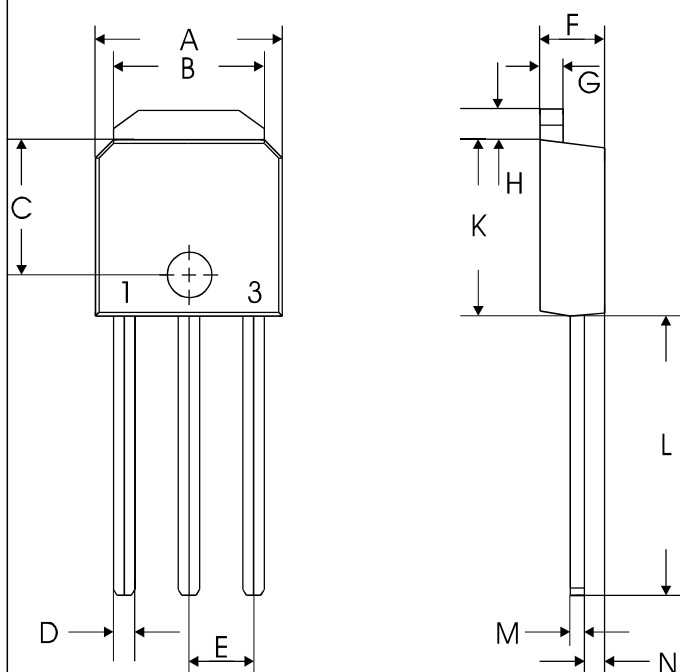
$$E_{oss}=f(V_{DS})$$



Definition of diodes switching characteristics

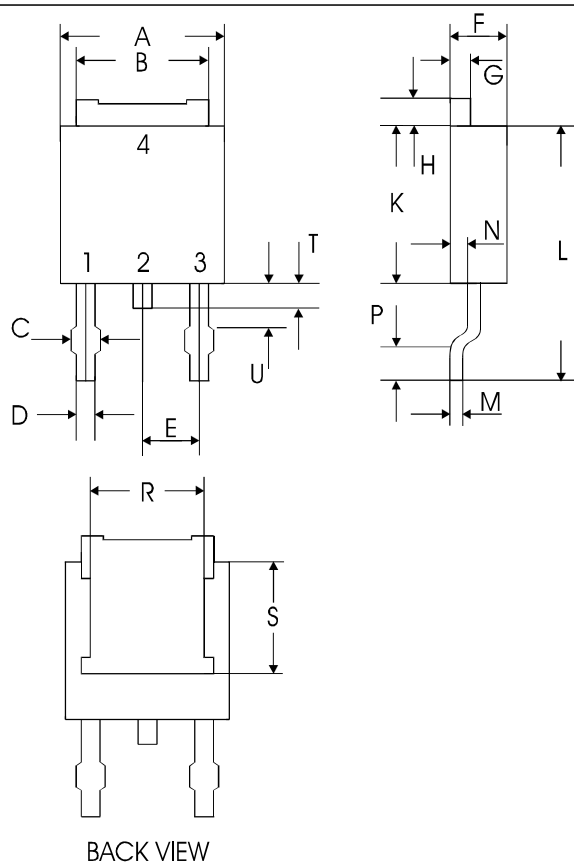


P-TO251 (I-Pak)



symbol	dimensions			
	[mm]		[inch]	
	min	max	min	max
A	6.47	6.73	0.2547	0.2650
B	5.25	5.41	0.2067	0.2130
C	4.19	4.43	0.1650	0.1744
D	0.63	0.89	0.0248	0.0350
E	2.29 typ.		0.0902 typ.	
F	2.18	2.39	0.0858	0.0941
G	0.76	0.86	0.0299	0.0339
H	1.01	1.11	0.0398	0.0437
K	5.97	6.23	0.2350	0.2453
L	9.14	9.65	0.3598	0.3799
M	0.46	0.56	0.0181	0.0220
N	0.98	1.15	0.0386	0.0453

P-TO252 (D-Pak)



symbol	dimensions			
	[mm]		inch	
	min	max	min	max
A	6.40	6.73	0.2520	0.2650
B	5.25	5.50	0.2067	0.2165
C	(0.65)	(1.15)	(0.0256)	(0.0453)
D	0.63	0.89	0.0248	0.0350
E	2.28		0.2520	
F	2.19	2.39	0.0862	0.0941
G	0.76	0.98	0.0299	0.0386
H	0.90	1.21	0.0354	0.0476
K	5.97	6.23	0.2350	0.2453
L	9.40	10.40	0.3701	0.4094
M	0.46	0.58	0.0181	0.0228
N	0.87	1.15	0.0343	0.0453
P	0.51	-	0.0201	-
R	5.00	-	0.1969	-
S	4.17	-	0.1642	-
T	0.26	1.02	0.0102	0.0402
U	-	-	-	-

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