

Cool MOS™ Power Transistor

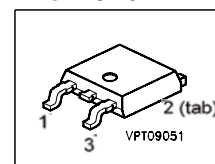
Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- Improved transconductance
- Pb-free lead plating; RoHS compliant, available in Halogen free mold compound^{a)}
- Fully qualified according to JEDEC for Industrial Applications

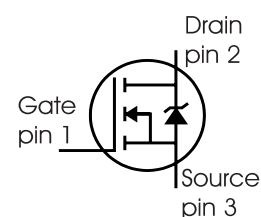
$V_{DS} @ T_{jmax}$	560	V
$R_{DS(on)}$	0.95	Ω
I_D	4.5	A



PG-TO252



Type	Package	Ordering Code	Marking
SPD04N50C3	PG-TO252	Q67040-S4574	04N50C3



Maximum Ratings

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	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	V_{GS}	± 20	V
Gate source voltage AC ($f > 1\text{ Hz}$)	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
Reverse diode dv/dt ⁵⁾	dv/dt	15	V/ns

^{a)} non-Halogen free (OPN: SPD04N50C3BT), Halogen free (OPN: SPD04N50C3AT)

Maximum Ratings

Parameter	Symbol	Value	Unit
Drain Source voltage slope $V_{DS} = 400 \text{ V}$, $I_D = 4.5 \text{ A}$, $T_j = 125^\circ\text{C}$	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}	-	-	62	
SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ²⁾	R_{thJA}	- -	- 35	62 -	
Soldering temperature, reflow soldering, MSL3 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	$V_{(BR)DSS}$	$V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$	500	-	-	V
Drain-Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS}=0\text{V}$, $I_D=4.5\text{A}$	-	600	-	
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}	$V_{DS}=500\text{V}$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$, $T_j=150^\circ\text{C}$	- -	0.1 -	1 100	μA
Gate-source leakage current	I_{GSS}	$V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$	-	-	100	
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	-	1.4	-	

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}	$V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1\text{MHz}$	-	470	-	pF
Output capacitance	C_{oss}		-	160	-	
Reverse transfer capacitance	C_{rss}		-	15	-	
Effective output capacitance, ³⁾ energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V to } 400\text{V}$	-	27	-	pF
Effective output capacitance, ⁴⁾ time related	$C_{o(tr)}$		-	44	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 350\text{V}$, $V_{GS} = 0/10\text{V}$, $I_D = 4.5\text{A}$, $R_G = 18\Omega$	-	10	-	ns
Rise time	t_r		-	5	-	
Turn-off delay time	$t_{d(off)}$		-	70	-	
Fall time	t_f		-	10	-	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 400\text{V}$, $I_D = 4.5\text{A}$	-	2.2	-	nC
Gate to drain charge	Q_{gd}		-	10	-	
Gate charge total	Q_g	$V_{DD} = 400\text{V}$, $I_D = 4.5\text{A}$, $V_{GS} = 0 \text{ to } 10\text{V}$	-	22	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 400\text{V}$, $I_D = 4.5\text{A}$	-	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 $I_{SD} \leq I_D$, $di/dt \leq 400\text{A/us}$, $V_{DClamp} = 400\text{V}$, $V_{peak} < V_{BR, DSS}$, $T_j < T_{j,max}$.

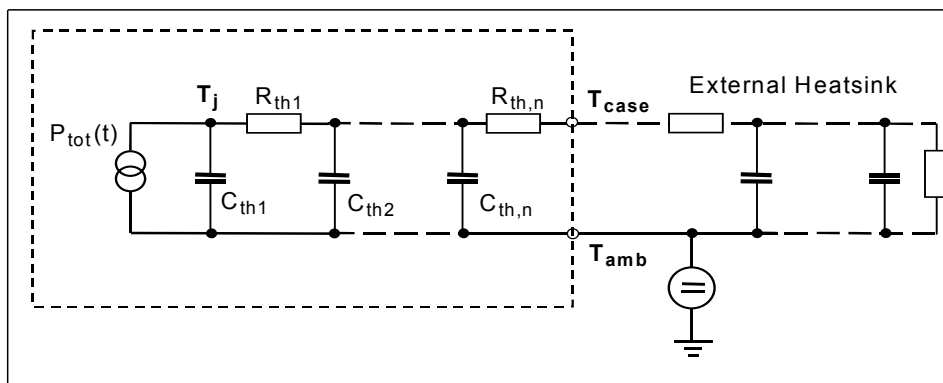
Identical low-side and high-side switch.

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}	$V_R=400\text{V}$, $I_F=I_S$, $di_F/dt=100\text{A}/\mu\text{s}$	-	280	-	ns
Reverse recovery charge	Q_{rr}		-	2.3	-	μC
Peak reverse recovery current	I_{rrm}		-	16	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt		-	860	-	$\text{A}/\mu\text{s}$

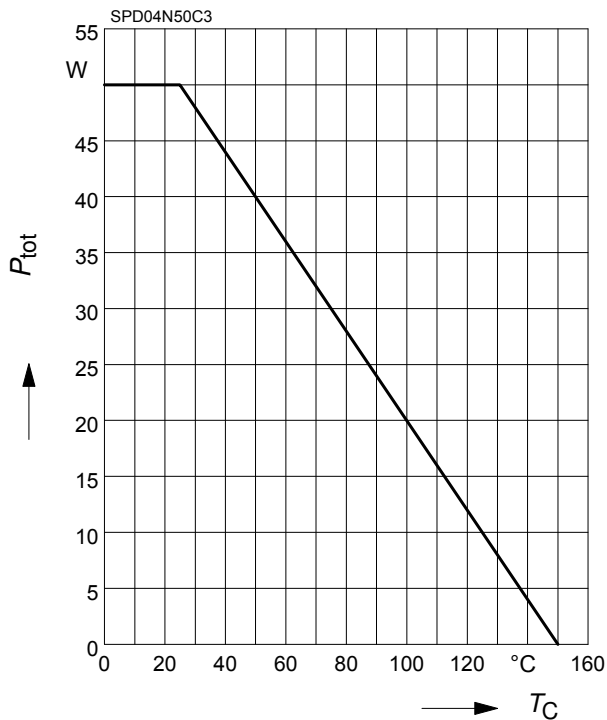
Typical Transient Thermal Characteristics

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

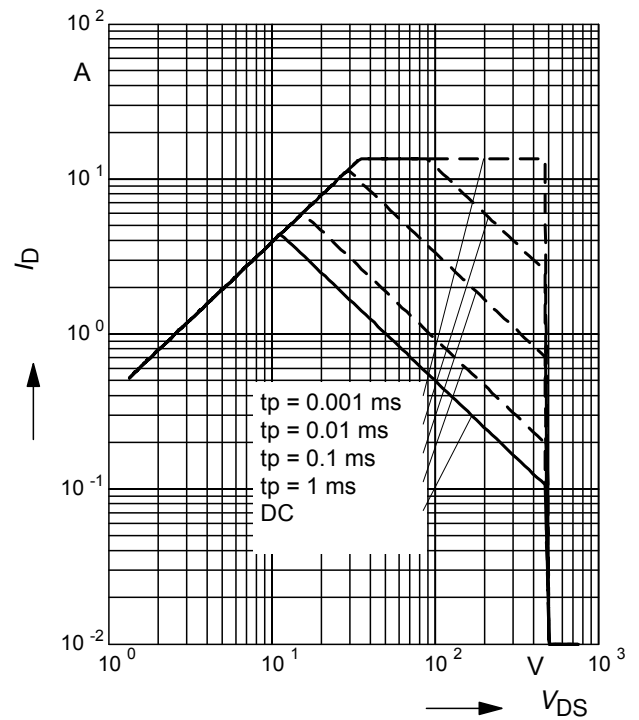
$$P_{\text{tot}} = f(T_C)$$



2 Safe operating area

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

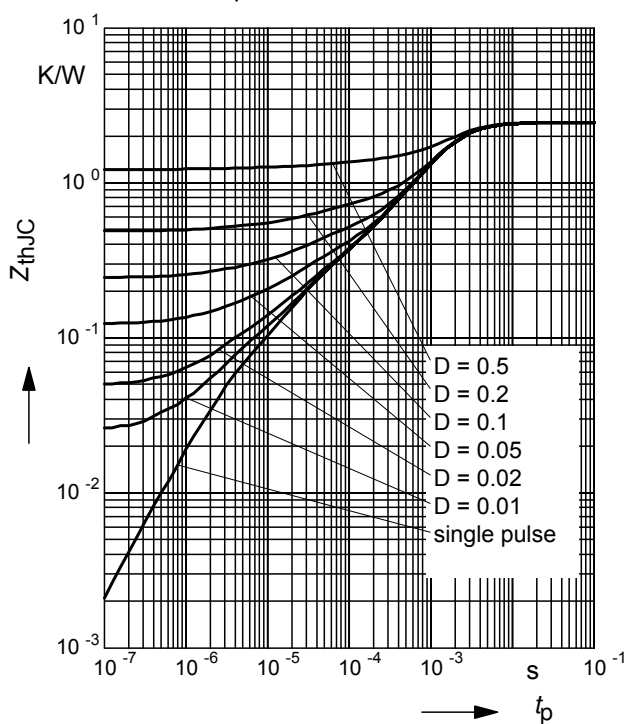
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



3 Transient thermal impedance

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

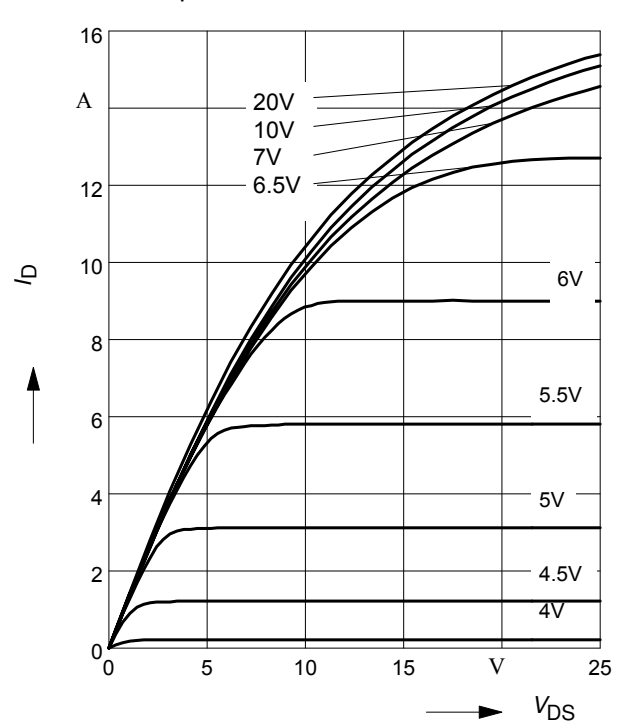
parameter: $D = t_p/T$



4 Typ. output characteristic

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

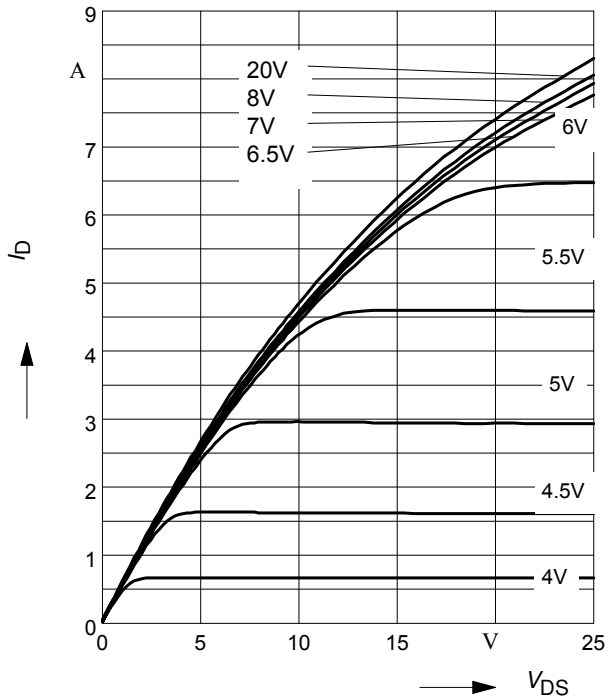
parameter: $t_p = 10 \mu\text{s}$, V_{GS}



5 Typ. output characteristic

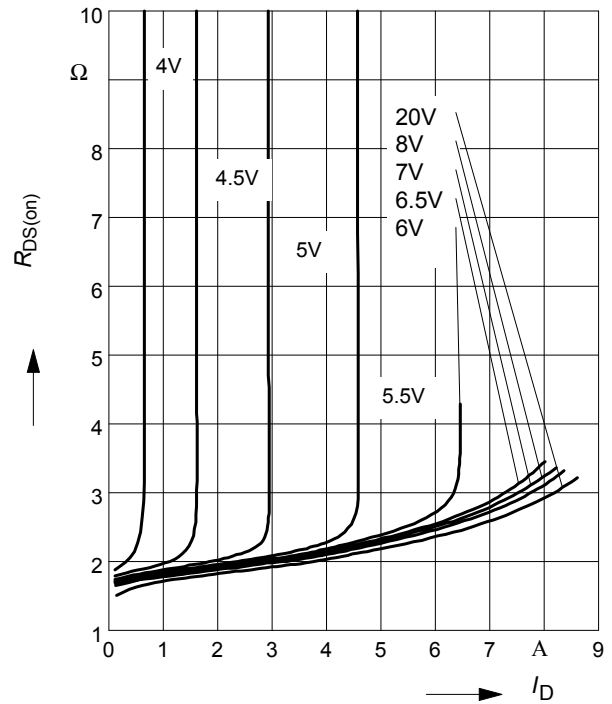
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

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


6 Typ. drain-source on resistance

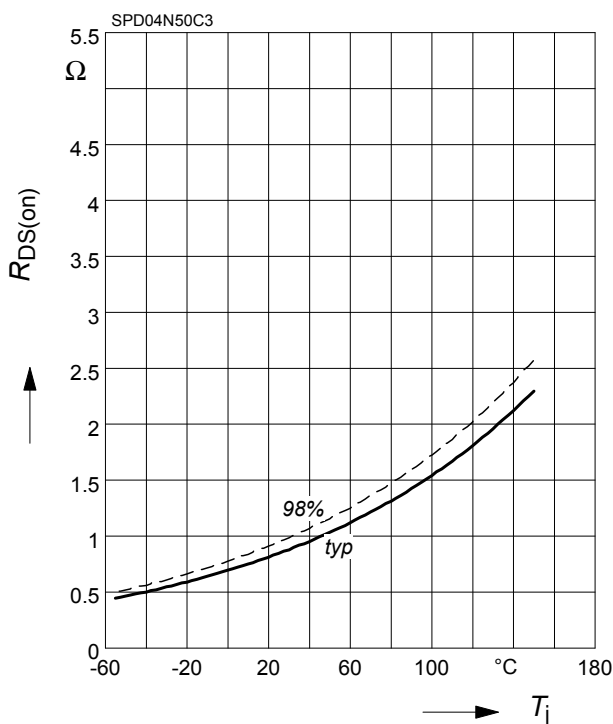
$$R_{DS(on)} = f(I_D)$$

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


7 Drain-source on-state resistance

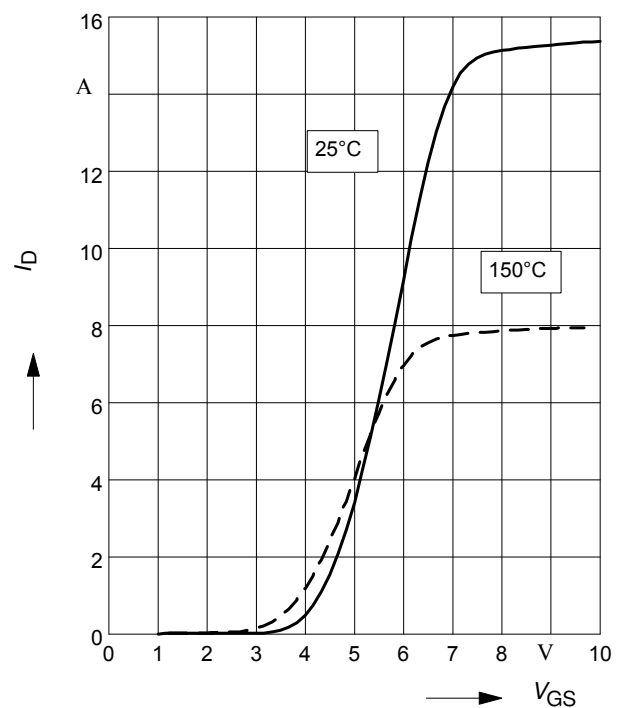
$$R_{DS(on)} = f(T_j)$$

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


8 Typ. transfer characteristics

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

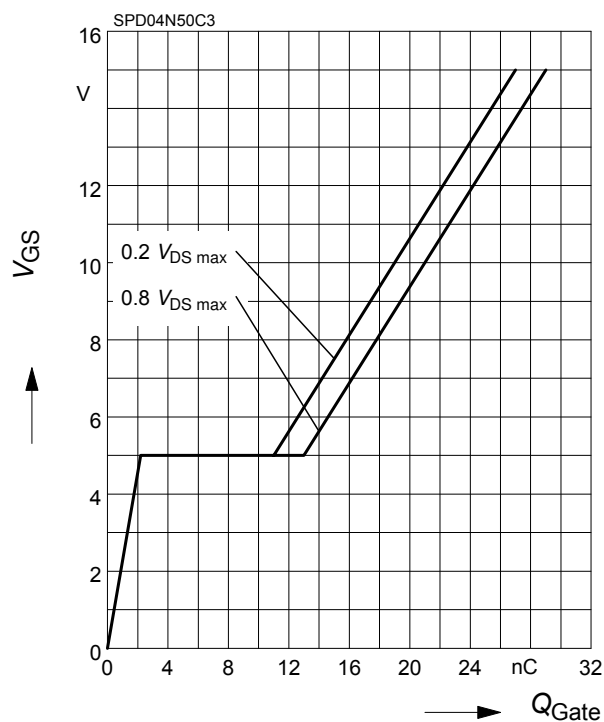
parameter: $t_p = 10 \mu\text{s}$



9 Typ. gate charge

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

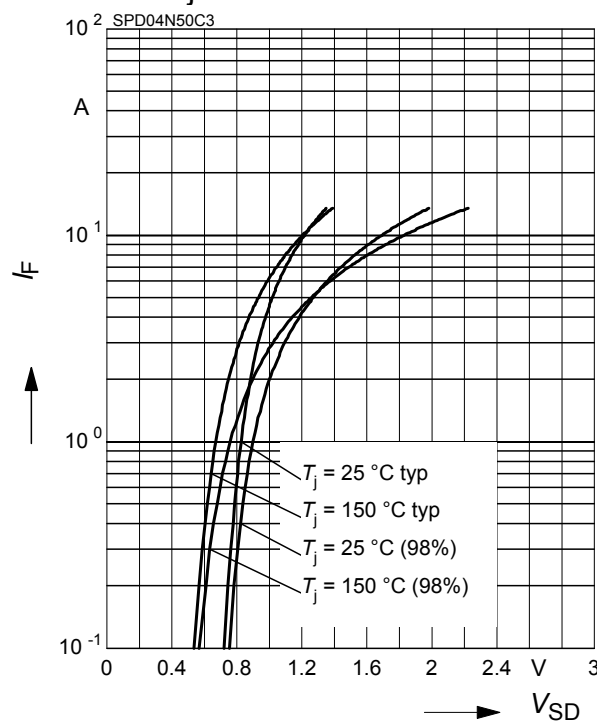
parameter: $I_D = 4.5$ A pulsed



10 Forward characteristics of body diode

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

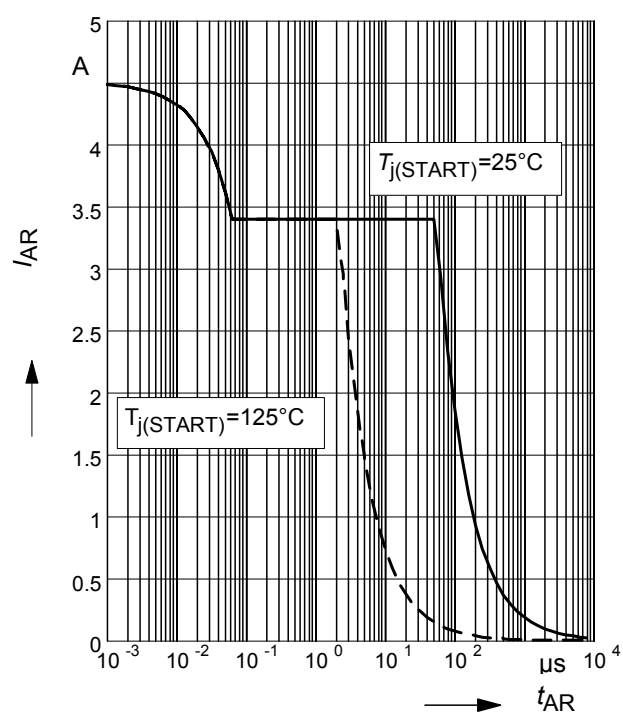
parameter: T_j , $t_p = 10$ μ s



11 Avalanche SOA

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

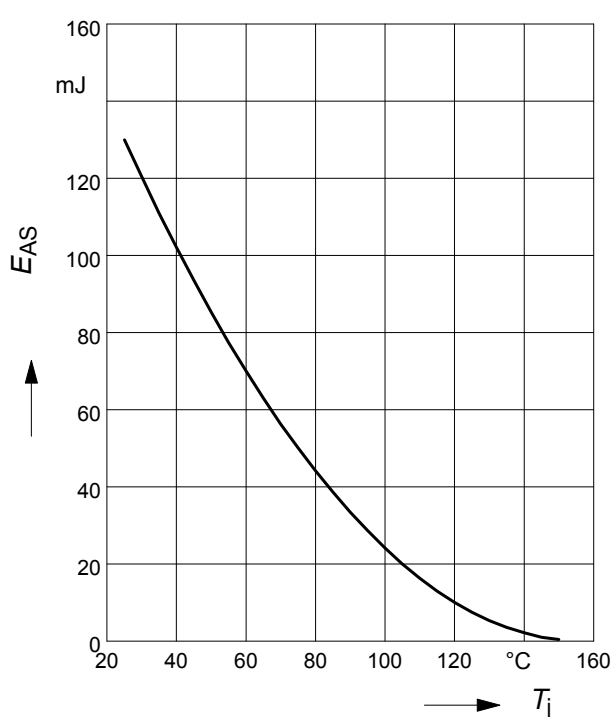
par.: $T_j \leq 150$ °C



12 Avalanche energy

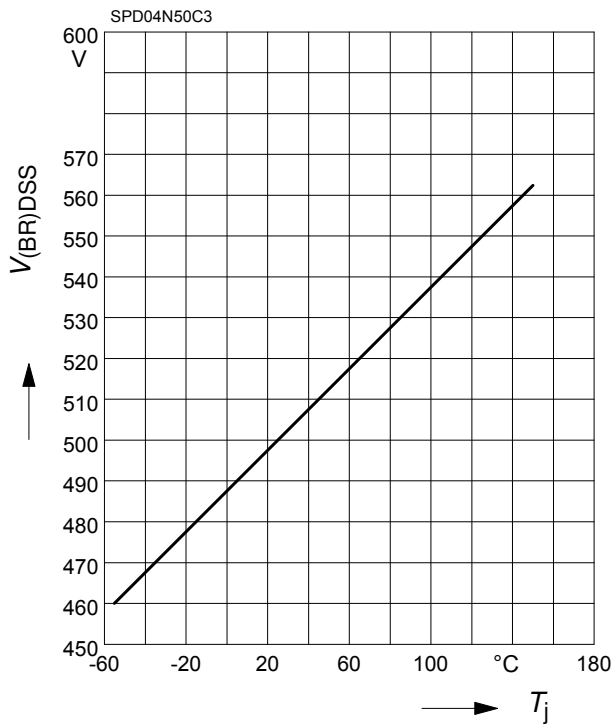
$$E_{AS} = f(T_j)$$

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



13 Drain-source breakdown voltage

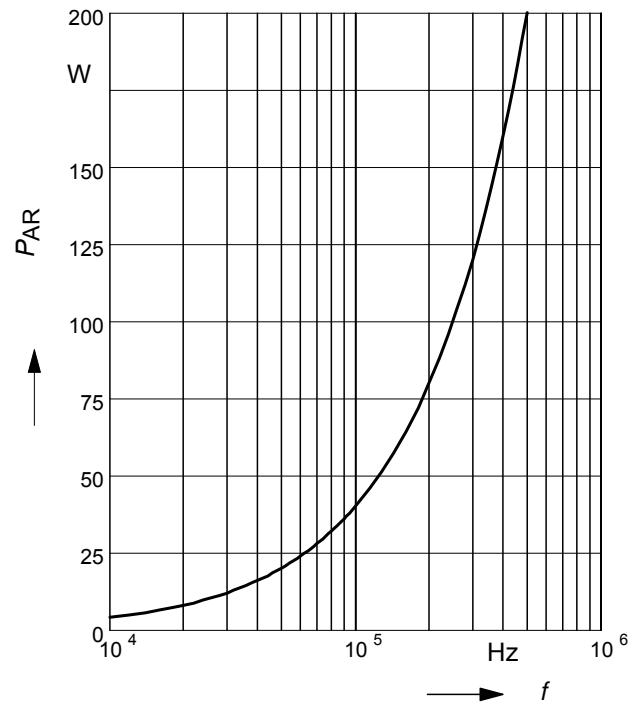
$$V_{(BR)DSS} = f(T_j)$$



14 Avalanche power losses

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

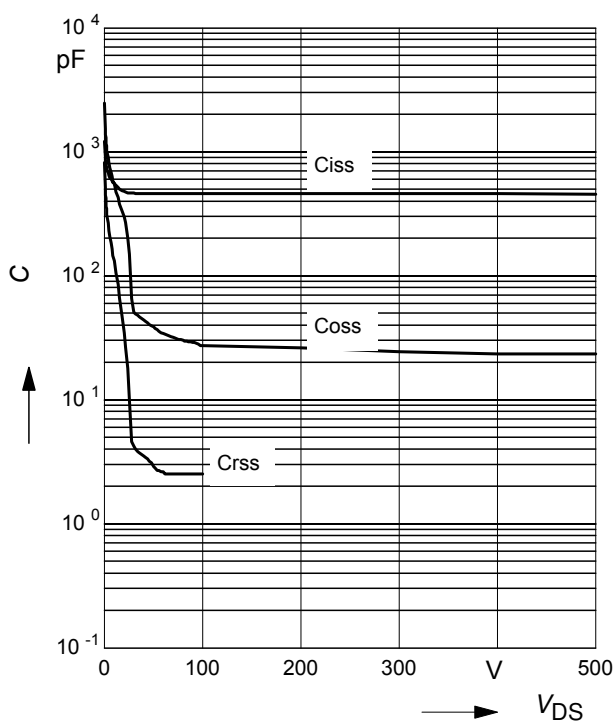
parameter: $E_{AR}=0.4\text{mJ}$



15 Typ. capacitances

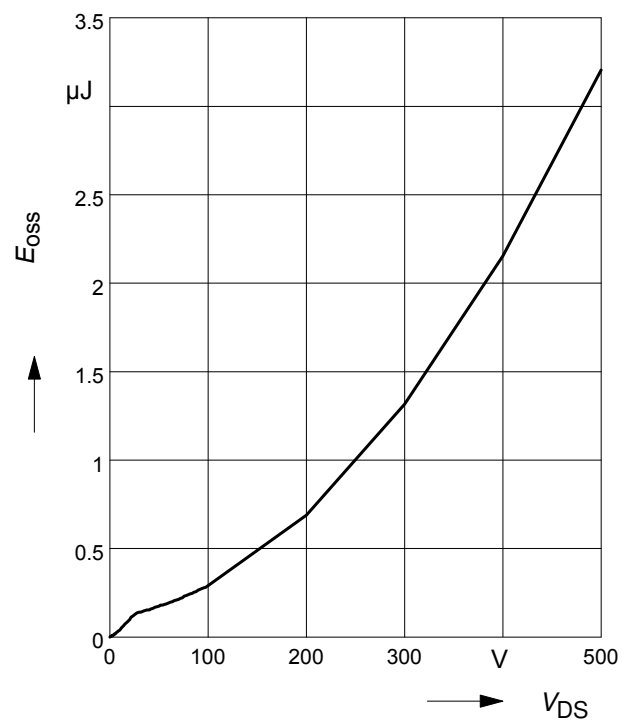
$$C = f(V_{DS})$$

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

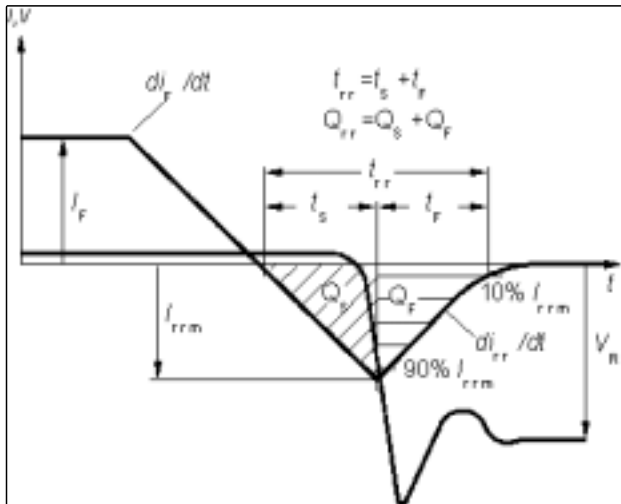


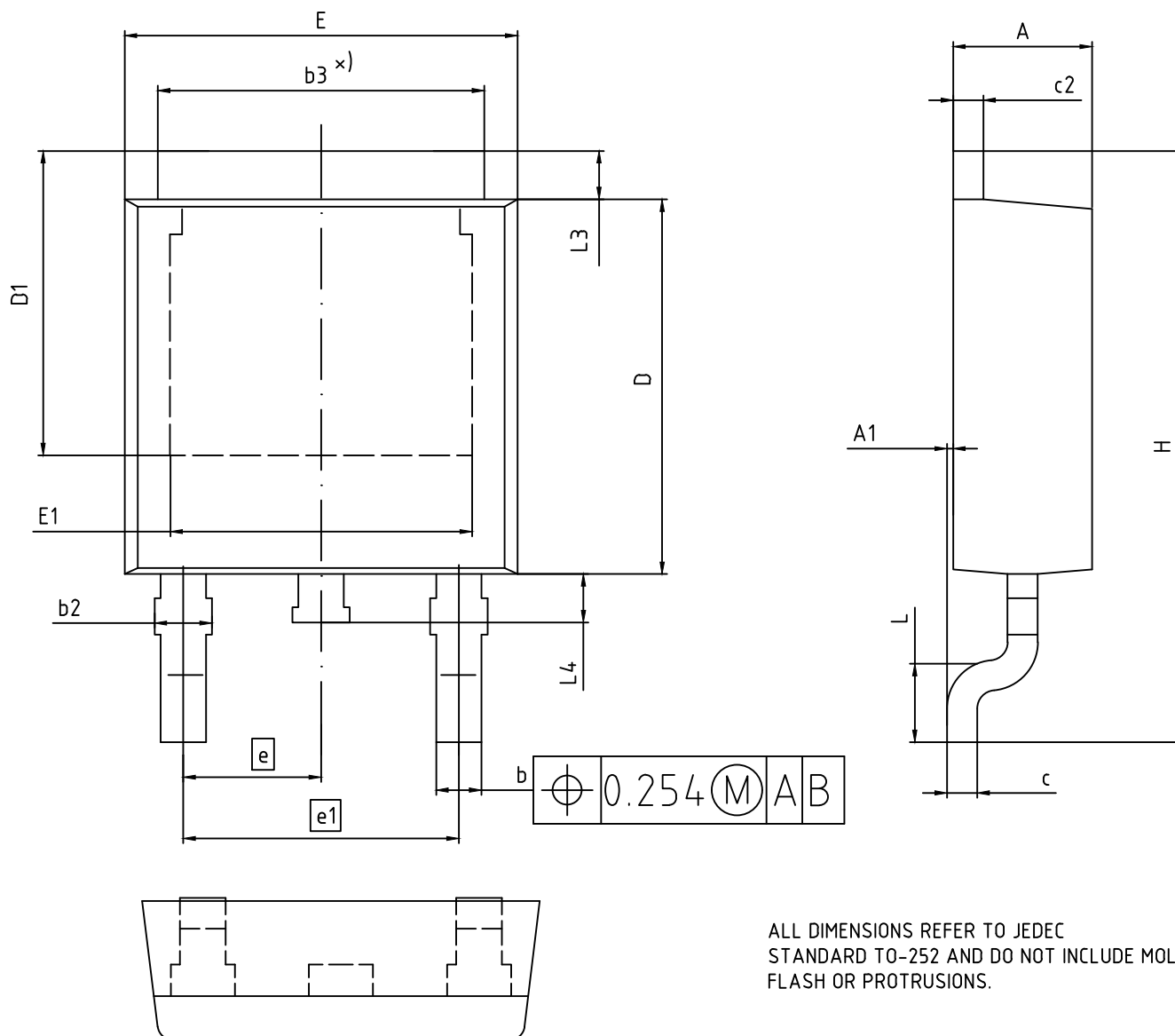
16 Typ. C_{oss} stored energy

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



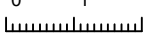
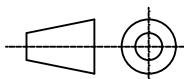
Definition of diodes switching characteristics



PG-TO252-3-1, PG-TO252-3-11, PG-TO252-3-21 (D-PAK)


ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

DIMENSION	MILLIMETERS	
	MIN.	MAX.
A	2.16	2.41
A1	0.00	0.15
b	0.64	0.89
b2	0.65	1.15
b3	4.95	5.50
c	0.46	0.61
c2	0.40	0.98
D	5.97	6.22
D1	5.02	5.84
E	6.35	6.73
E1	4.32	5.50
e	2.29	
e1	4.57	
N	3	
H	9.40	10.48
L	1.18	1.78
L3	0.89	1.27
L4	0.51	1.02

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Revision History

SPD04N50C3

Revision: 2020-05-26, Rev. 2.7

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.7	2020-05-26	Update package outline

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