

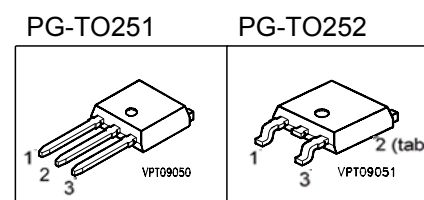
## Cool MOS™ Power Transistor

### Feature

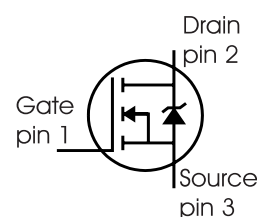
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- Pb-free lead plating; RoHS compliant, available in Halogen free mold compound<sup>a)</sup>
- Fully qualified according to JEDEC for Industrial Applications



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



Type	Package	Marking
SPD04N60C3	PG-TO252	04N60C3
SPU04N60C3	PG-TO251	04N60C3



### 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 $T_{jmax}$ <sup>1</sup> $I_D = 4.5\text{ A}$ , $V_{DD} = 50\text{ V}$	$E_{AR}$	0.4	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	4.5	A
Gate source voltage static	$V_{GS}$	$\pm 20$	V
Gate source voltage AC ( $f > 1\text{ Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25\text{ °C}$	$P_{tot}$	50	W
Operating and storage temperature	$T_j, T_{stg}$	-55... +150	$^{\circ}\text{C}$
Reverse diode dv/dt <sup>5)</sup>	dv/dt	15	V/ns

<sup>a)</sup> non-Halogen free (OPN: SPD04N60C3BT), Halogen free (OPN: SPD04N60C3AT)

**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 <sup>2</sup> cooling area <sup>2)</sup>	$R_{thJA}$	-	-	75 50	
Soldering temperature, *) 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	$\mu\text{A}$
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 -	$\Omega$
Gate input resistance	$R_G$	$f=1\text{MHz}$ , open Drain	-	0.95	-	

\*) TO252: reflow soldering, MSL1; TO251: wavesoldering

**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, <sup>3)</sup> energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	20	-	pF
Effective output capacitance, <sup>4)</sup> 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

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

<sup>2</sup> Device on 40mm\*40mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

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

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

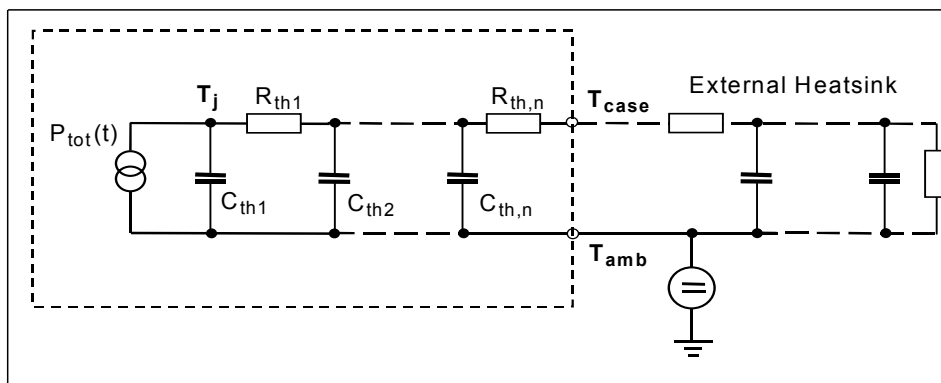
<sup>5</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 400\text{A}/\mu\text{s}$ ,  $V_{DClink} = 400\text{V}$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .  
Identical low-side and high-side switch.

**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	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	18	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	-	900	$\text{A}/\mu\text{s}$

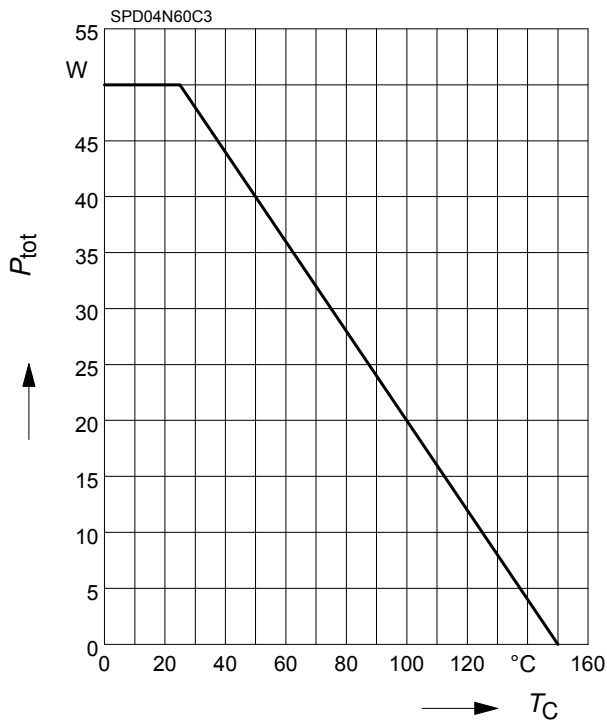
**Typical Transient Thermal Characteristics**

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

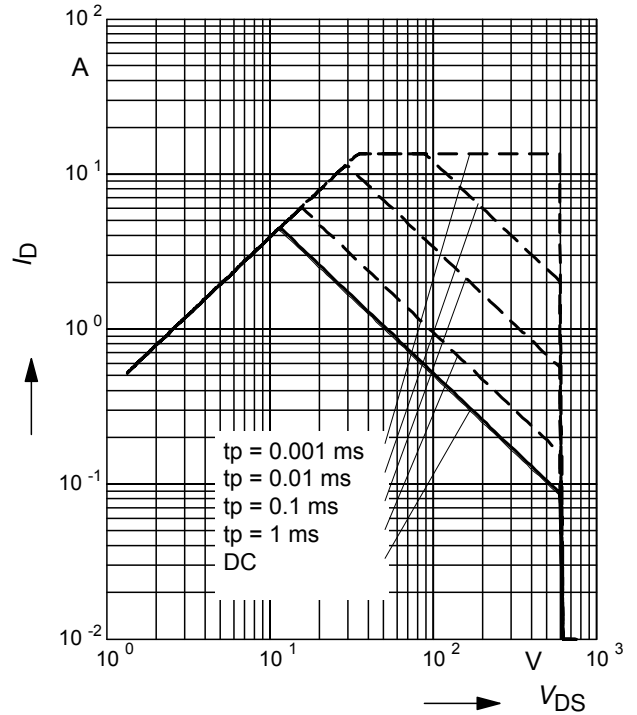
$$P_{tot} = f(T_C)$$



### 2 Safe operating area

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

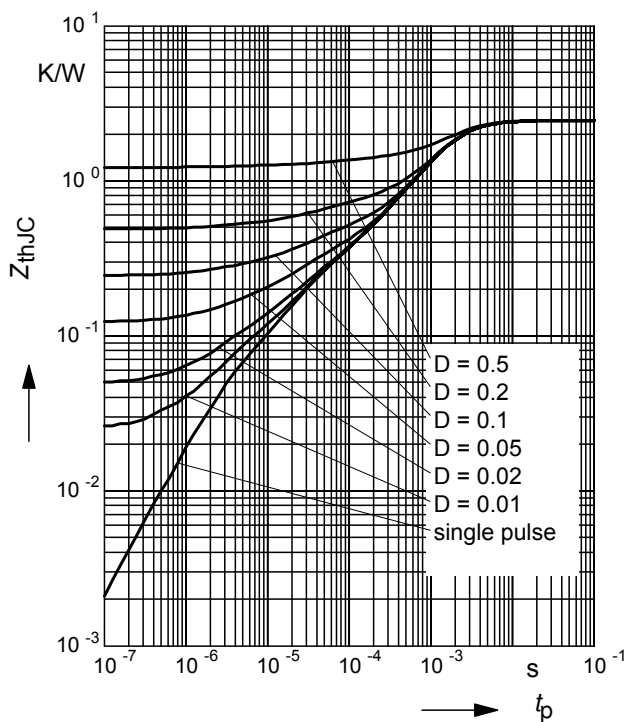
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

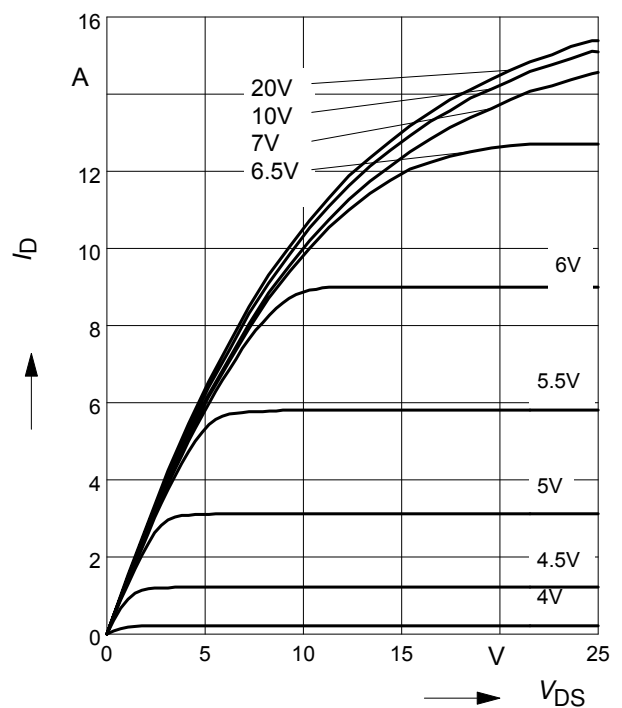
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

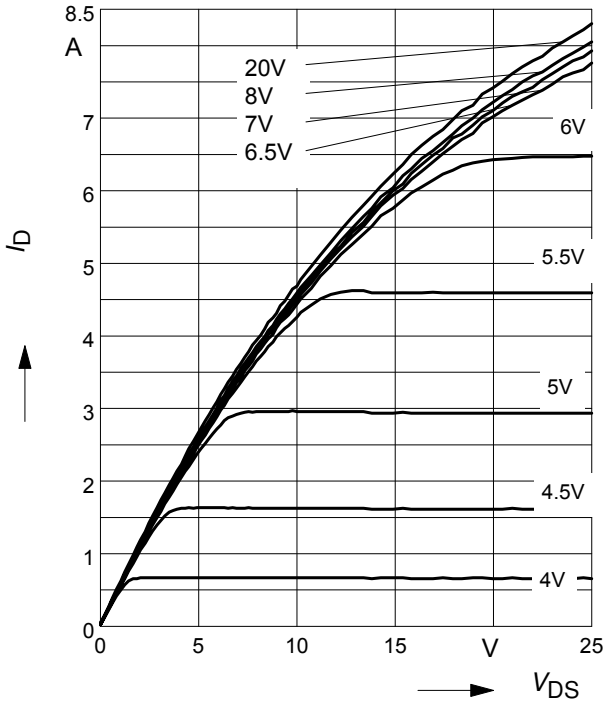
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



**5 Typ. output characteristic**

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

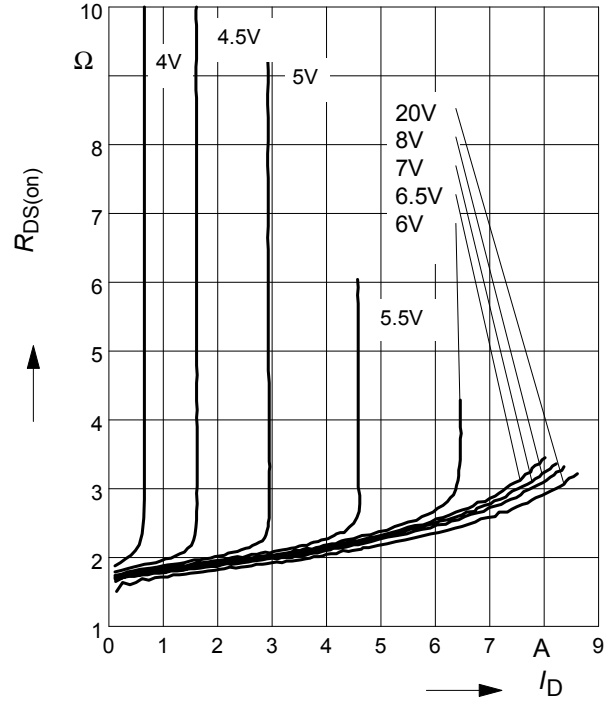
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**6 Typ. drain-source on resistance**

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

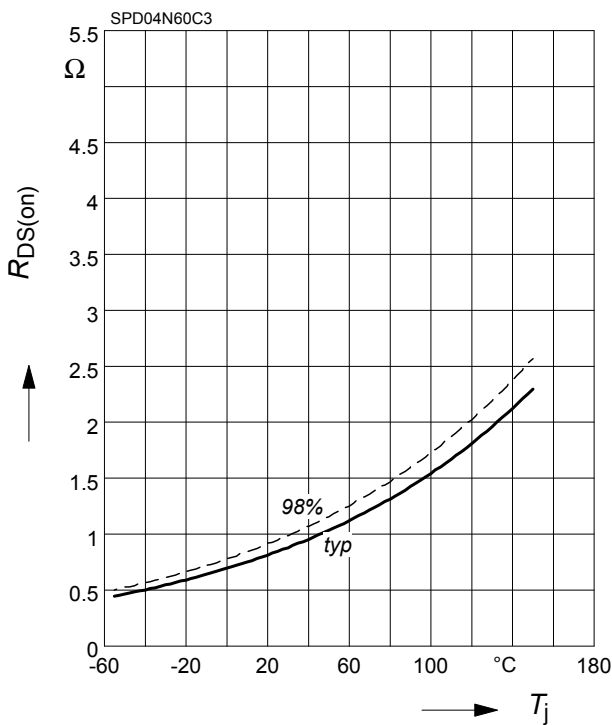
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



**7 Drain-source on-state resistance**

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

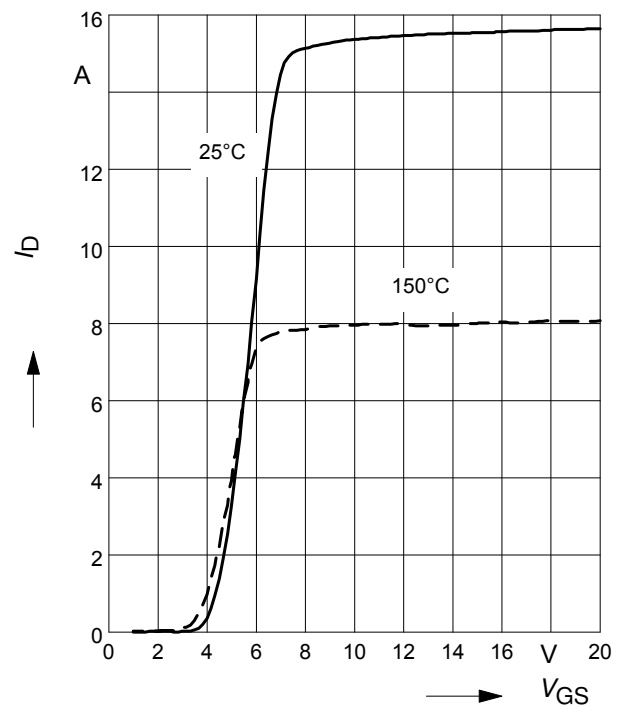
parameter:  $I_D = 2.8 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

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

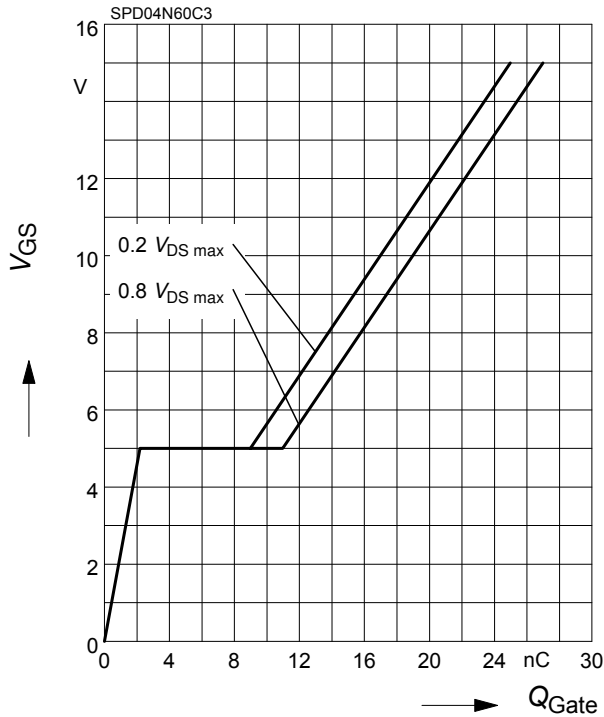
parameter:  $t_p = 10 \mu\text{s}$



### 9 Typ. gate charge

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

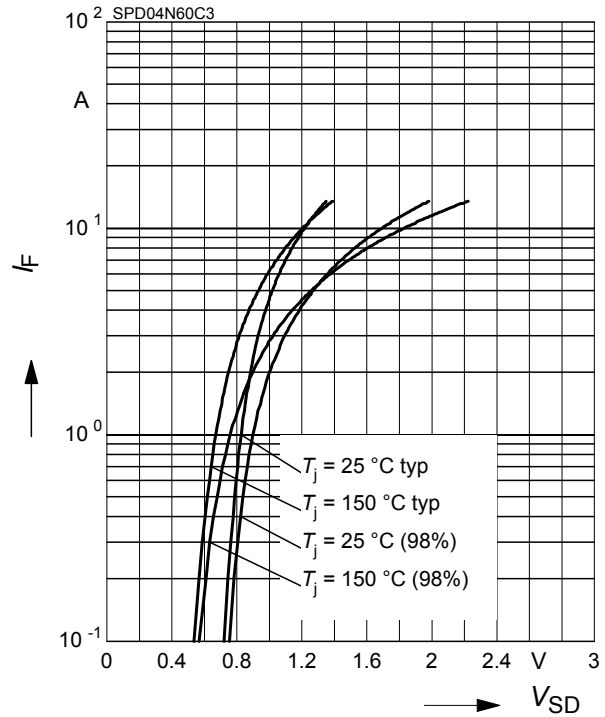
parameter:  $I_D = 4.5$  A pulsed



### 10 Forward characteristics of body diode

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

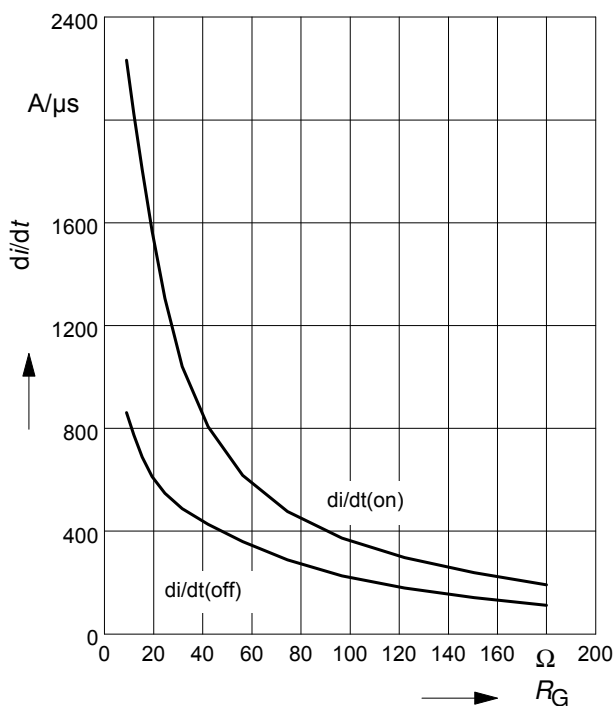
parameter:  $T_j, t_p = 10$   $\mu$ s



### 11 Typ. drain current slope

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

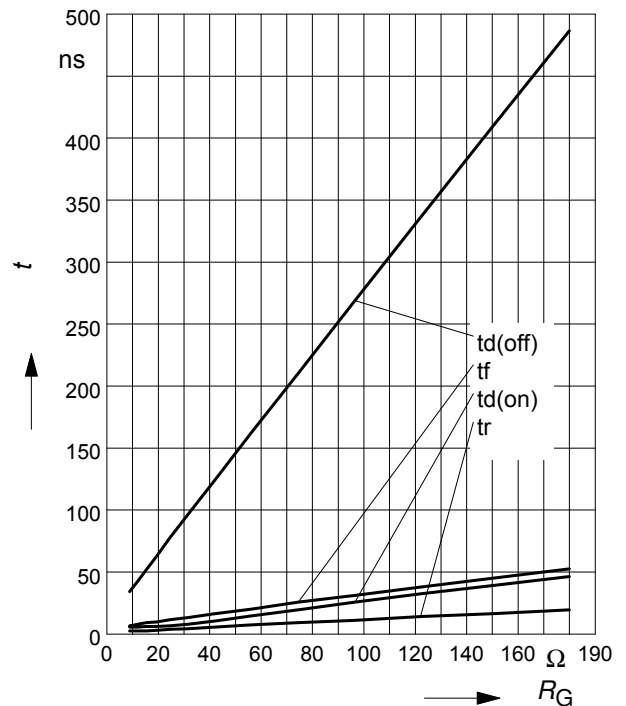
par.:  $V_{DS}=380$ V,  $V_{GS}=0/+13$ V,  $I_D=4.5$ A



### 12 Typ. switching time

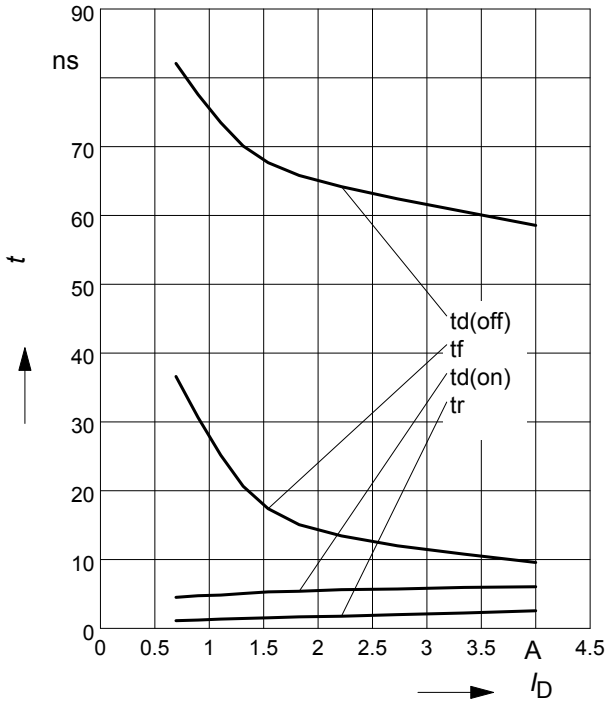
$$t = f(R_G), \text{ inductive load, } T_j=125^\circ\text{C}$$

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



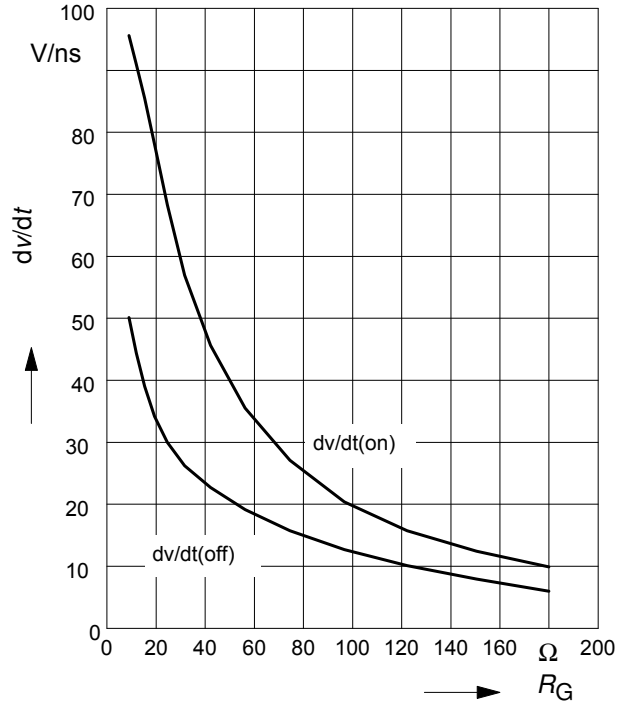
**13 Typ. switching time**

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



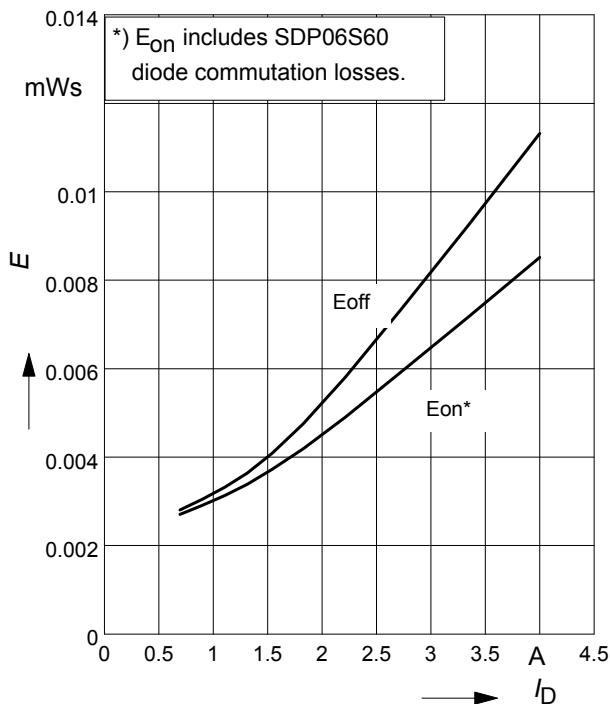
**14 Typ. drain source voltage slope**

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



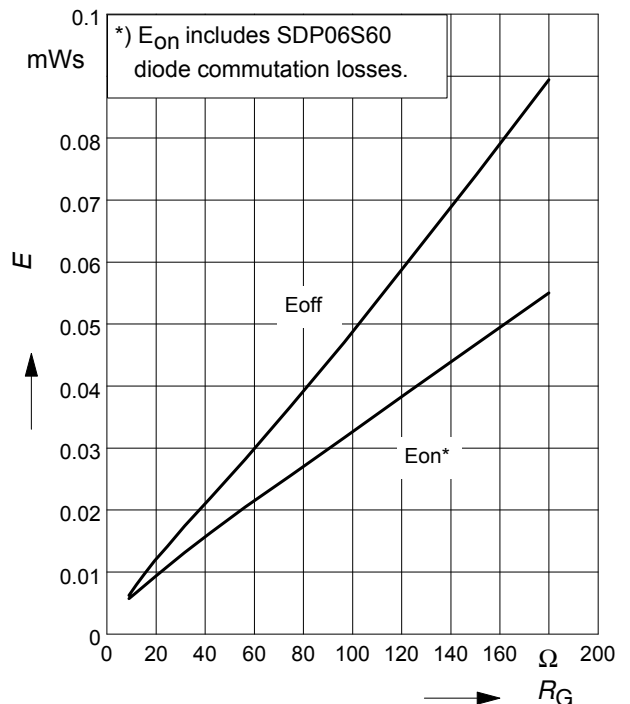
**15 Typ. switching losses**

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

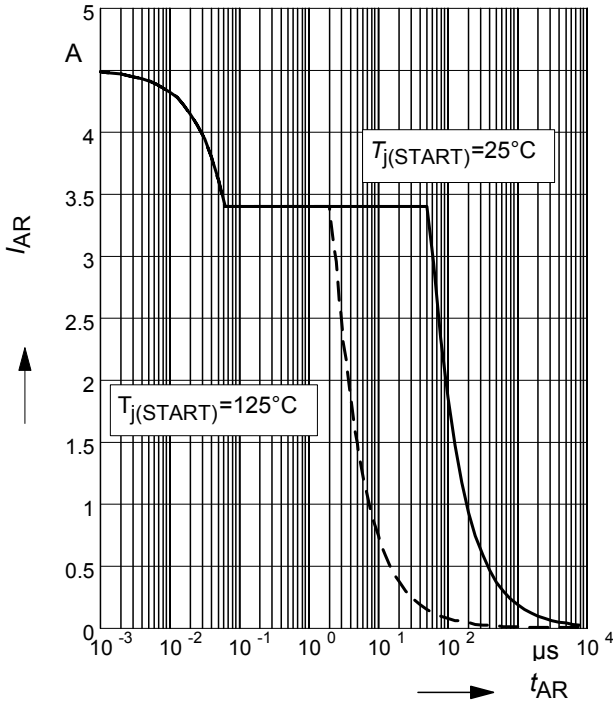




### 17 Avalanche SOA

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

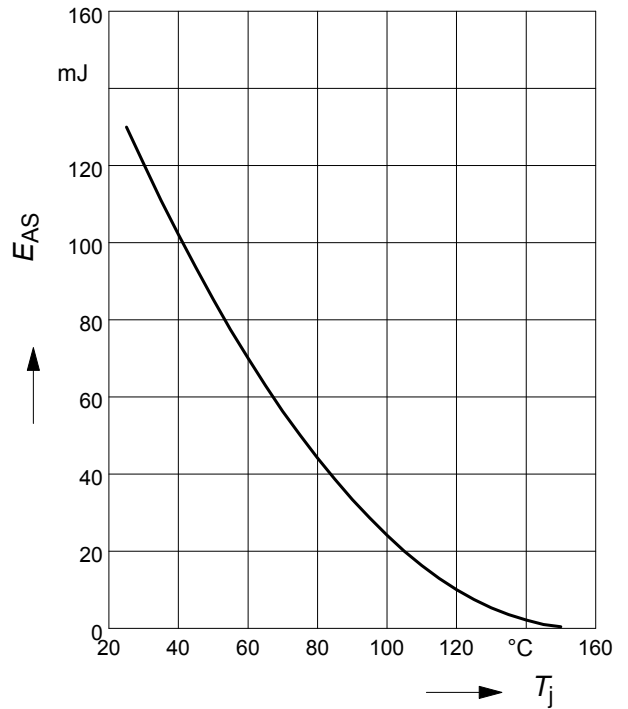
par.:  $T_j \leq 150^\circ\text{C}$



### 18 Avalanche energy

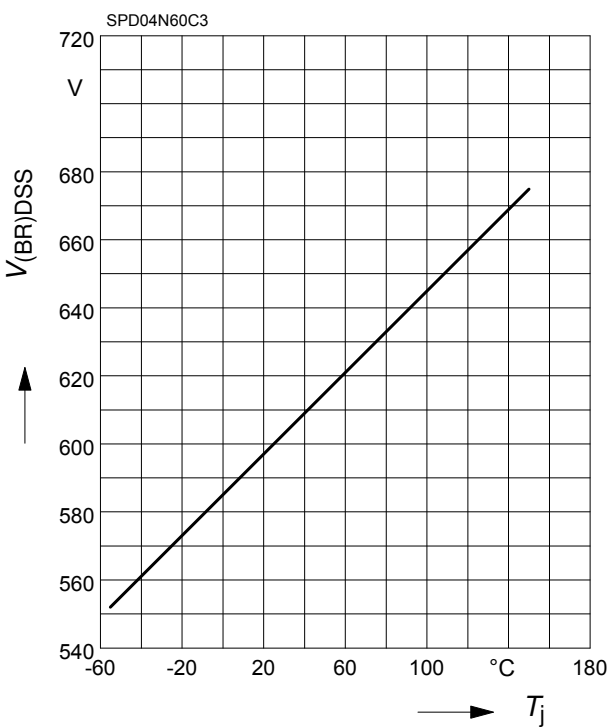
$$E_{AS} = f(T_j)$$

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



### 19 Drain-source breakdown voltage

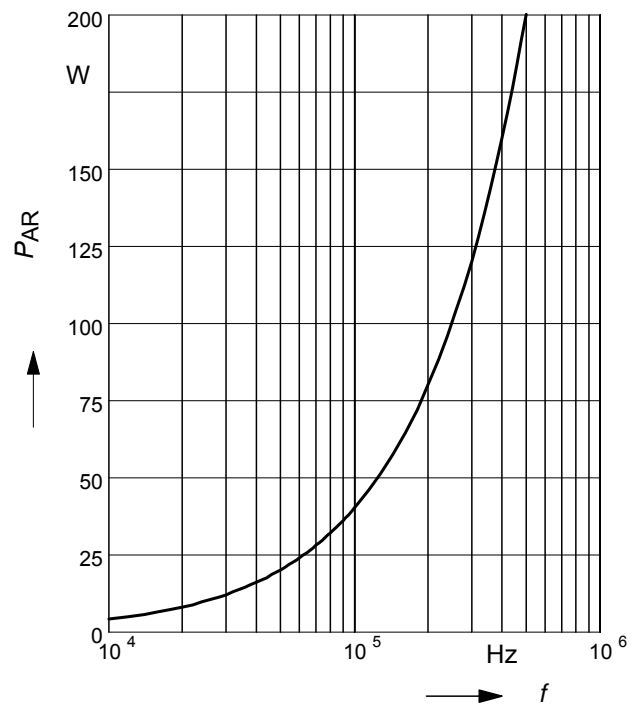
$$V_{(BR)DSS} = f(T_j)$$



### 20 Avalanche power losses

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

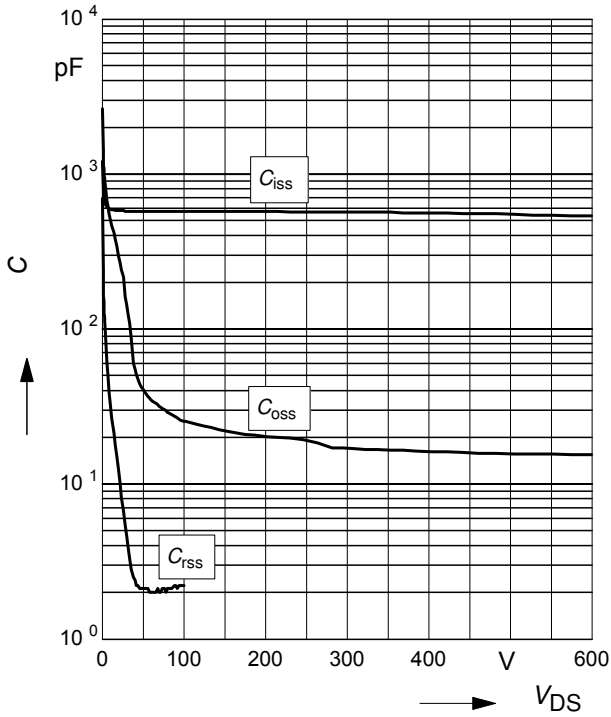
parameter:  $E_{AR} = 0.4\text{ mJ}$



**21 Typ. capacitances**

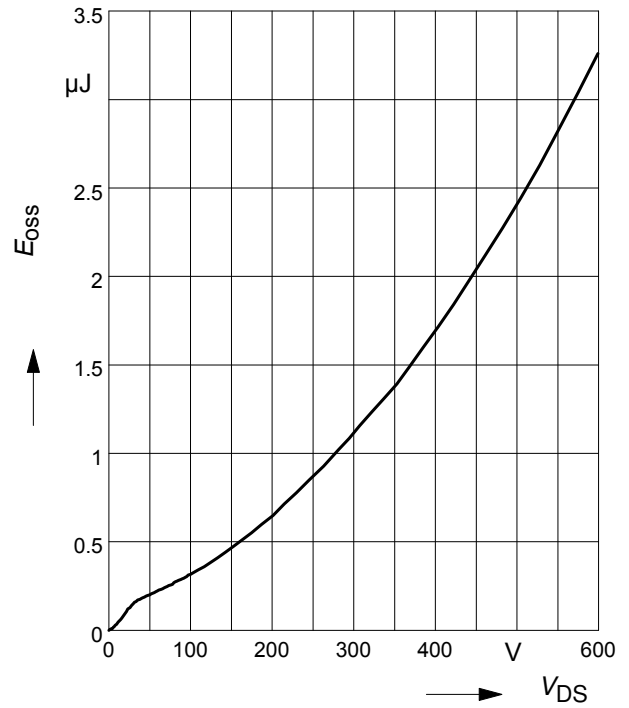
$C = f(V_{DS})$

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

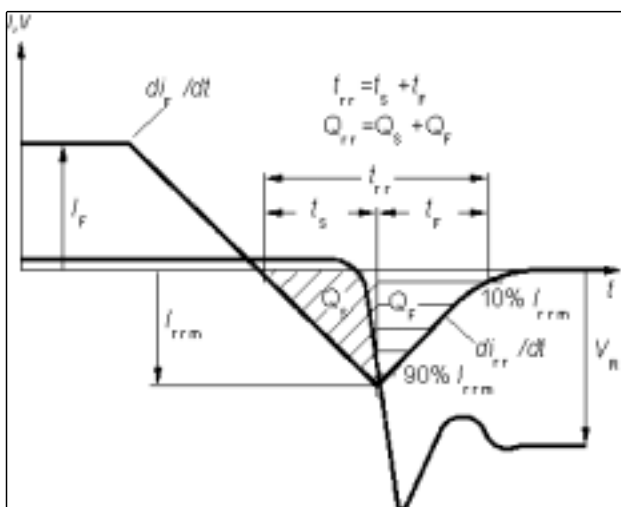


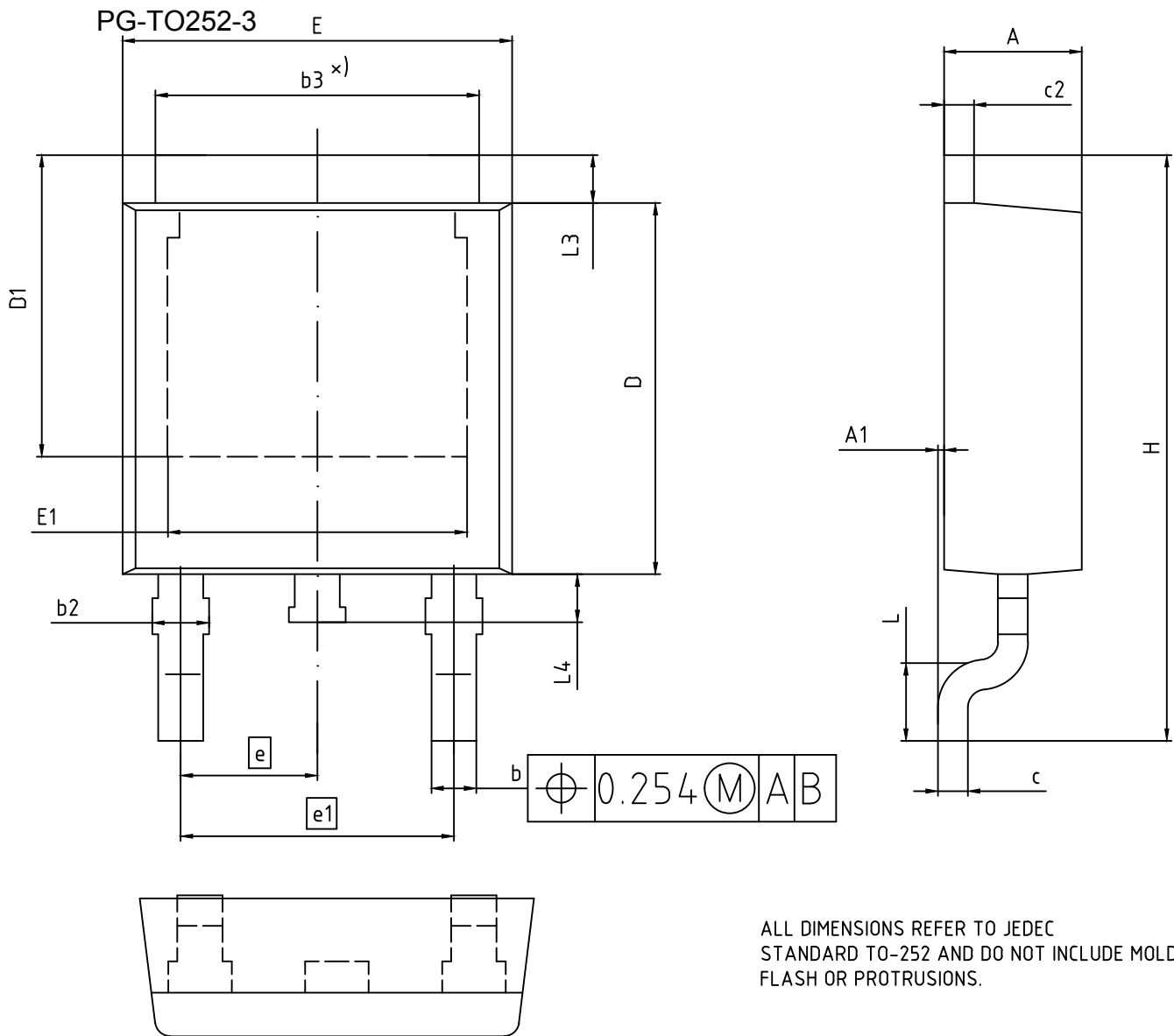
**22 Typ.  $C_{oss}$  stored energy**

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



**Definition of diodes switching characteristics**



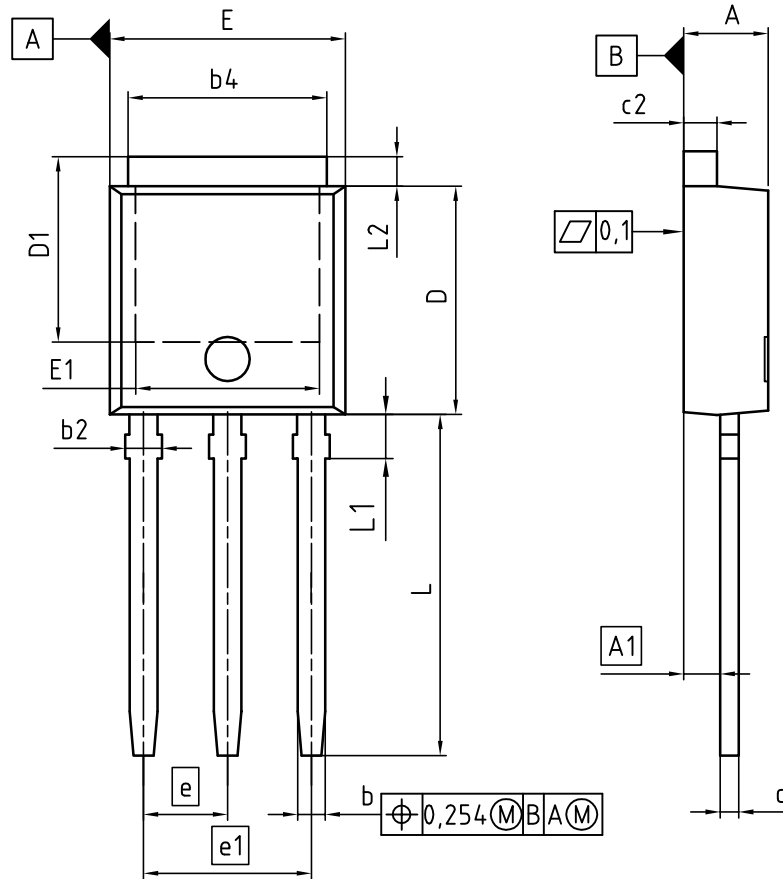


ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

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

<b>DOCUMENT NO.</b> Z8B00003328
<b>REVISION</b> 07
<b>SCALE:</b> 10:1 0 1 2mm 
<b>EUROPEAN PROJECTION</b> 
<b>ISSUE DATE</b> 01.04.2020

PG-TO251-3



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.16	2.41	0.085	0.095
A1	0.90	1.14	0.035	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	0.60	0.018	0.024
c2	0.46	0.89	0.018	0.035
D	5.97	6.22	0.235	0.245
D1	5.04	5.77	0.198	0.227
E	6.35	6.73	0.250	0.265
E1	4.70	5.21	0.185	0.205
e	2.29		0.090	
e1	4.57		0.180	
N	3		3	
L	8.89	9.65	0.350	0.380
L1	1.90	2.29	0.075	0.090
L2	0.89	1.37	0.035	0.054

DOCUMENT NO.  
DZ80001310

SCALE

EUROPEAN PROJECTION

ISSUE DATE  
19-03-2008

REVISION  
03

## Revision History

SPD04N60C3

**Revision: 2020-05-26, Rev. 2.6**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.6	2020-05-26	Update package outline

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