

## Cool MOS™ Power Transistor

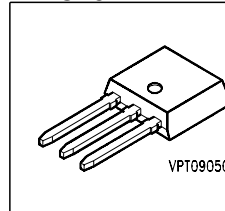
### Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Improved noise immunity

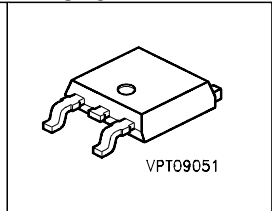
### Product Summary

$V_{DS}$	600	V
$R_{DS(on)}$	0.95	$\Omega$
$I_D$	4.5	A

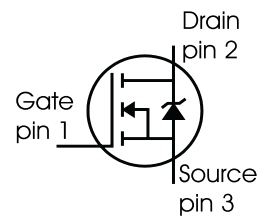
P-TO251



P-TO252



Type	Package	Ordering Code	Marking
SPD04N60C2	P-TO252	Q67040-S4307	04N60C2
SPU04N60C2	P-TO251	Q67040-S4306	04N60C2



### Maximum Ratings, at $T_C = 25^\circ\text{C}$ , unless otherwise specified

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	$I_D$	4.5 2.8	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\ puls}$	9	
Avalanche energy, single pulse $I_D=3.6\text{A}$ , $V_{DD}=50\text{V}$	$E_{AS}$	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
Reverse diode $dv/dt$ $I_S=4.5\text{A}$ , $V_{DS} < V_{DD}$ , $di/dt=100\text{A}/\mu\text{s}$ , $T_{jmax}=150^\circ\text{C}$	$dv/dt$	6	V/ns
Gate source voltage	$V_{GS}$	$\pm 20$	V
Power dissipation, $T_C = 25^\circ\text{C}$	$P_{tot}$	50	W
Operating and storage temperature	$T_j, T_{stg}$	-55... +150	$^\circ\text{C}$

### Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
<b>Characteristics</b>					
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	
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, $V_{GS} = V_{DS}$ $I_D=200\mu A, T_j=25\text{ °C}$	$V_{GS(th)}$	3.5	4.5	5.5	
Zero gate voltage drain current $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}, T_j = 25\text{ °C}$ $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}, T_j = 150\text{ °C}$	$I_{DSS}$	-	0.5	1 50	$\mu A$
Gate-source leakage current $V_{GS}=20V, V_{DS}=0V$	$I_{GSS}$	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=2.8A, T_j=25\text{ °C}$	$R_{DS(on)}$	-	0.85	0.95	$\Omega$
Gate input resistance $f = 1\text{ MHz}, \text{open drain}$	$R_G$	-	0.95	-	

<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  $\mu m$  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.	
<b>Characteristics</b>						
Transconductance	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ $I_D = 2.8\text{A}$	-	2.5		S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,	-	580	-	pF
Output capacitance	$C_{oss}$	$f = 1\text{MHz}$	-	220	-	
Reverse transfer capacitance	$C_{rss}$		-	7	-	
Effective output capacitance, 1) energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V}$ to $480\text{V}$	-	20	-	pF
Effective output capacitance, 2) time related	$C_{o(tr)}$		-	35	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380\text{V}$ , $V_{GS} = 0/13\text{V}$ ,	-	10	-	ns
Rise time	$t_r$	$I_D = 4.5\text{A}$ , $R_G = 18\Omega$ ,	-	31	-	
Turn-off delay time	$t_{d(off)}$	$T_j = 125^\circ\text{C}$	-	44	66	
Fall time	$t_f$		-	12.5	18.8	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 350\text{V}$ , $I_D = 4.5\text{A}$	-	4.5	-	nC
Gate to drain charge	$Q_{gd}$		-	11	-	
Gate charge total	$Q_g$	$V_{DD} = 350\text{V}$ , $I_D = 4.5\text{A}$ , $V_{GS} = 0$ to $10\text{V}$	-	17.6	22.9	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 350\text{V}$ , $I_D = 4.5\text{A}$	-	8	-	V

<sup>1</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%  $V_{DSS}$ .

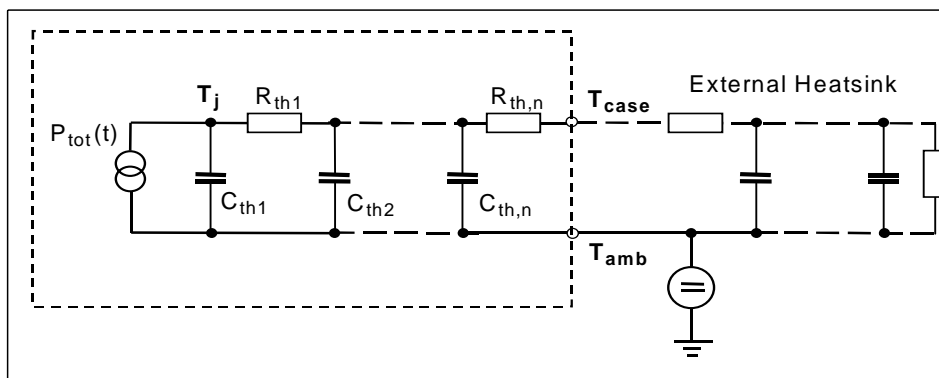
<sup>2</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Inverse diode continuous forward current	$I_S$	$T_C=25^\circ\text{C}$	-	-	4.5	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	9	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=350\text{V}, I_F=I_S,$	-	900	1530	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	3.2	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	12	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	440	-	$\text{A}/\mu\text{s}$

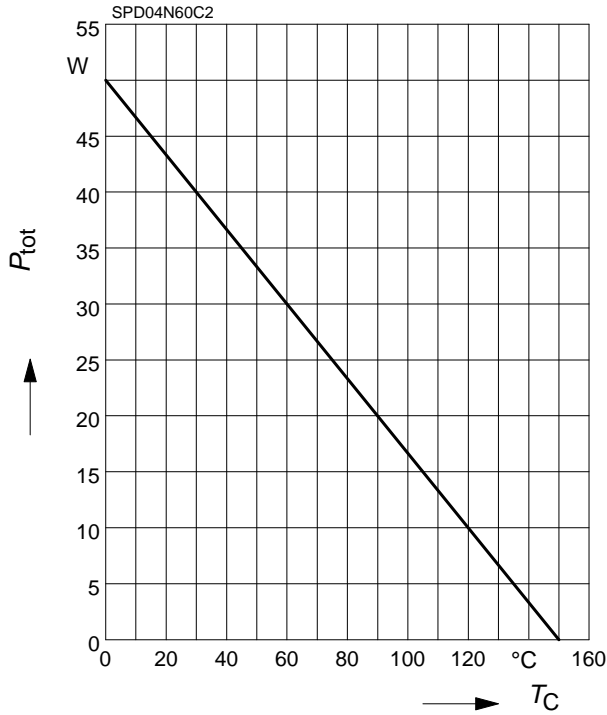
Typical Transient Thermal Characteristics

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
$R_{th1}$	0.039	K/W	$C_{th1}$	0.00008293	Ws/K
$R_{th2}$	0.083		$C_{th2}$	0.000282	
$R_{th3}$	0.101		$C_{th3}$	0.0004859	
$R_{th4}$	0.262		$C_{th4}$	0.0006523	
$R_{th5}$	0.294		$C_{th5}$	0.005017	
$R_{th6}$	0.094		$C_{th6}$	0.052	



### 1 Power dissipation

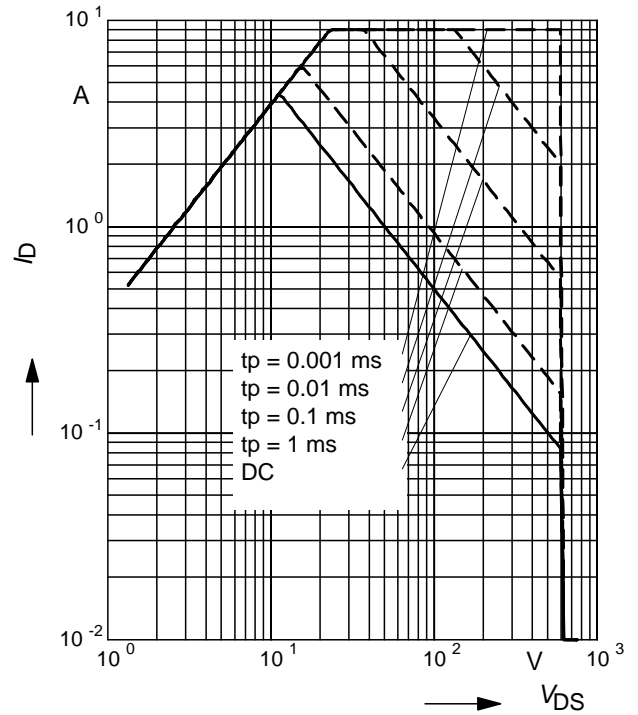
$$P_{tot} = f(T_C)$$



### 2 Safe operating area

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

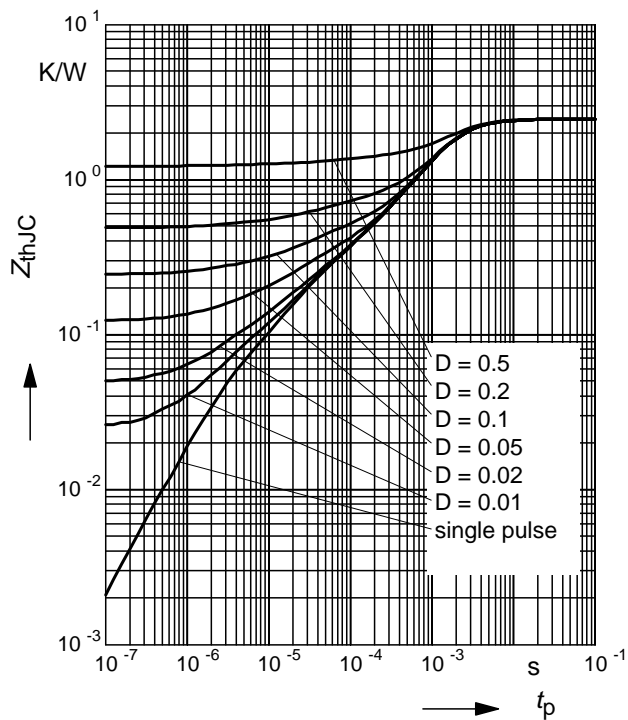
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

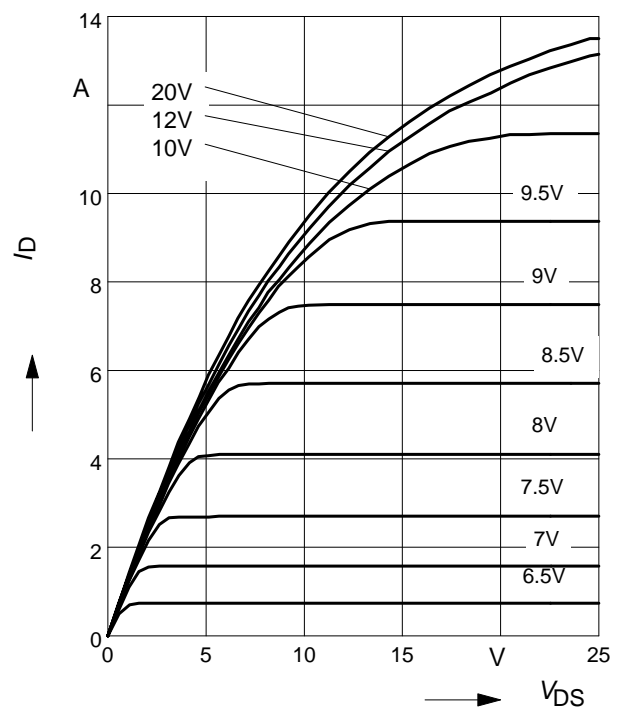
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

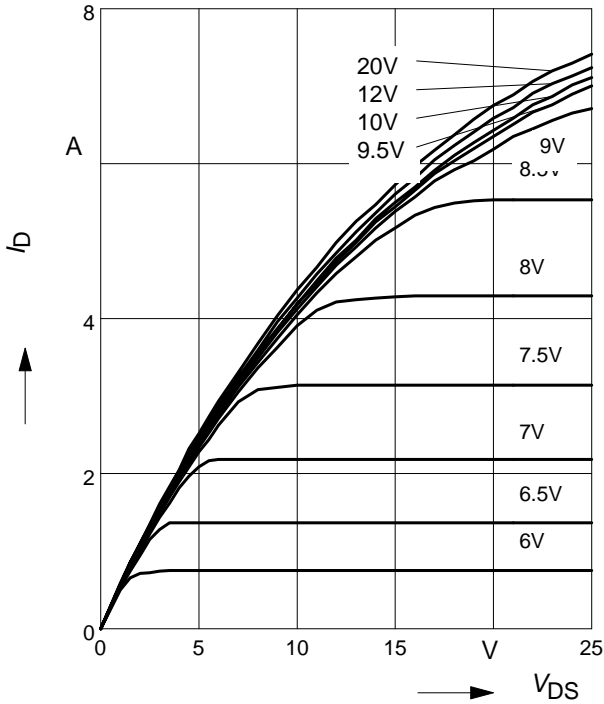
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



**5 Typ. output characteristic**

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

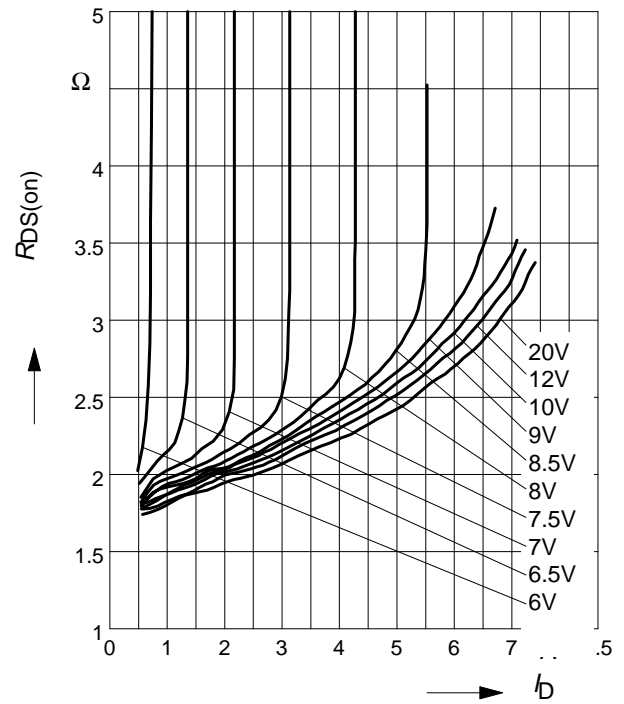
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

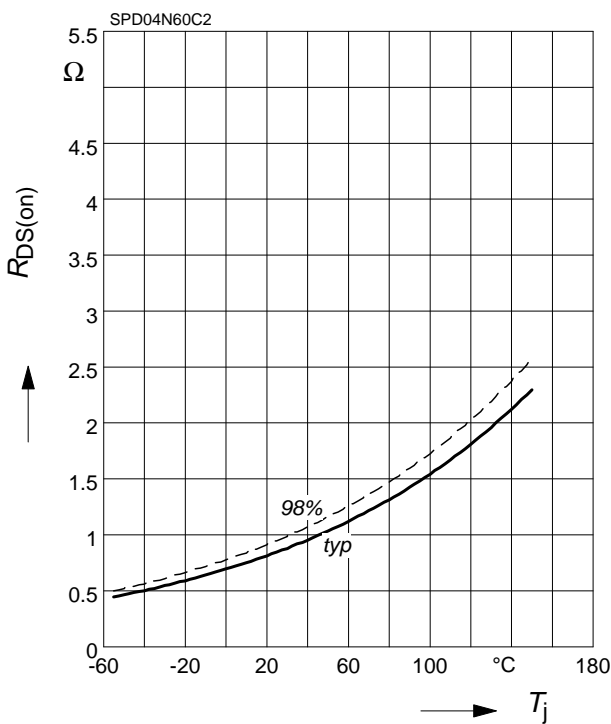
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



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

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

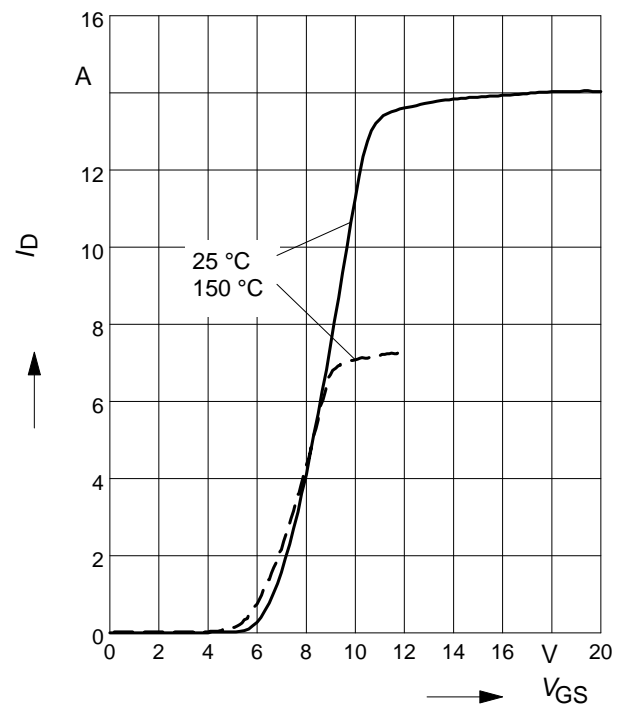
parameter:  $I_D = 2.8 \text{ A}, V_{GS} = 10 \text{ V}$



**8 Typ. transfer characteristics**

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

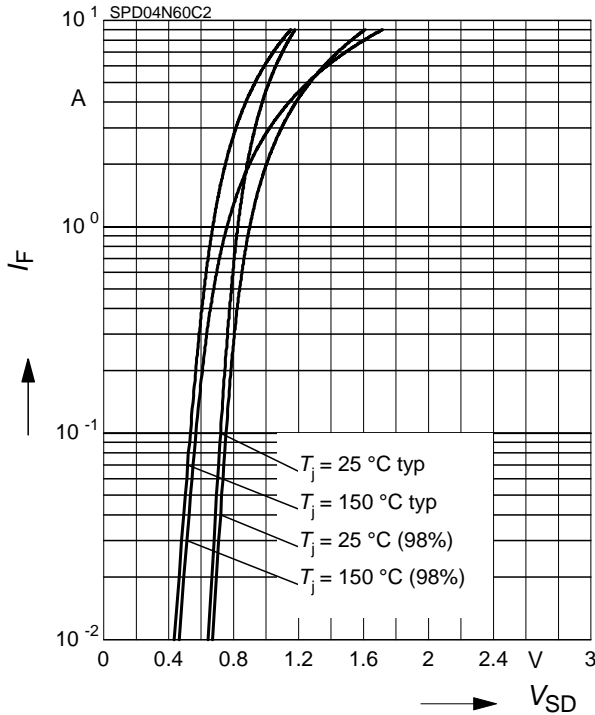
parameter:  $t_p = 10 \mu\text{s}$



**9 Forward characteristics of body diode**

$I_F = f(V_{SD})$

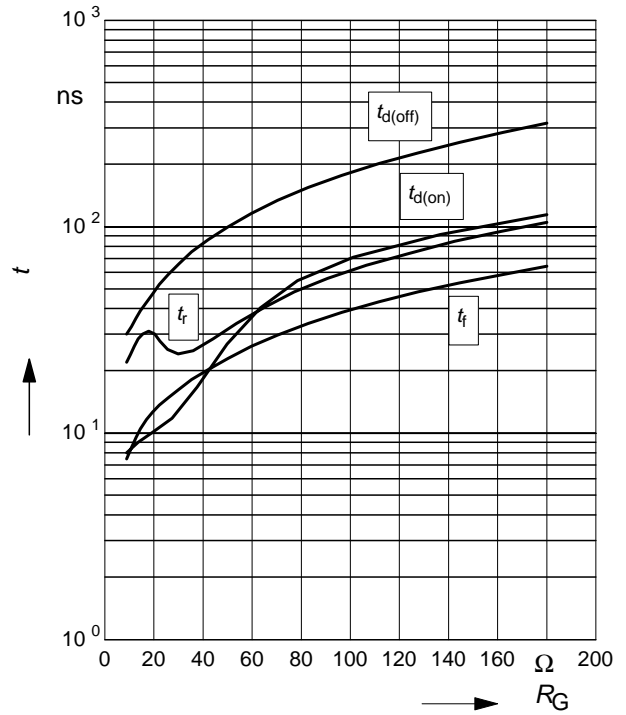
parameter:  $T_j$ ,  $t_p = 10 \mu s$



**10 Typ. switching time**

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

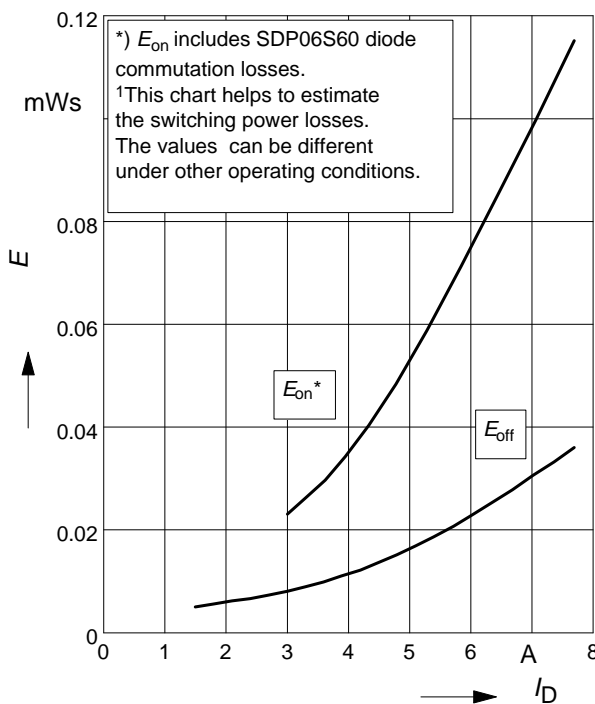
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $I_D=4.5 A$



**11 Typ. switching losses<sup>1)</sup>**

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

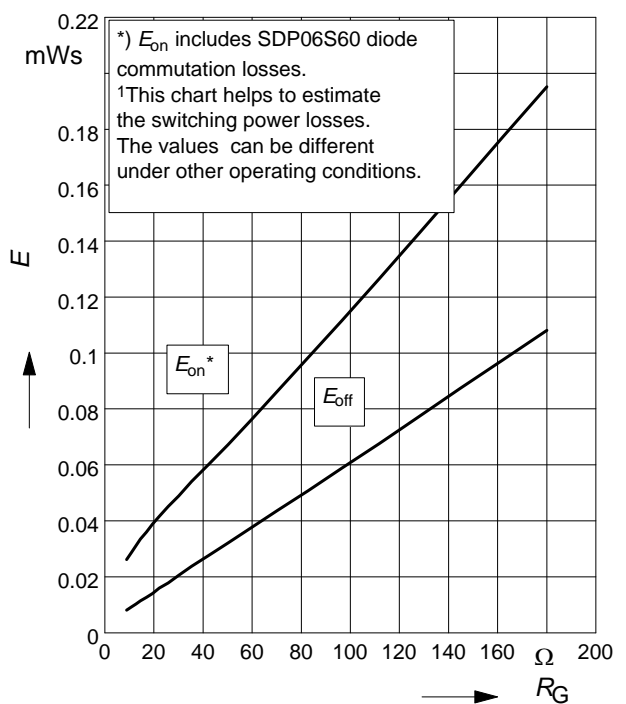
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $R_G=18\Omega$



**12 Typ. switching losses<sup>1)</sup>**

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

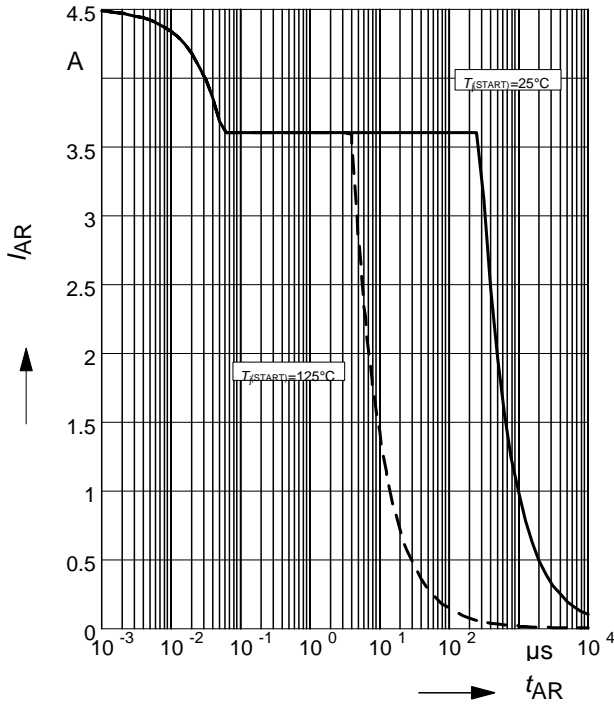
par.:  $V_{DS}=380V$ ,  $V_{GS}=0/+13V$ ,  $I_D=4.5A$



**13 Avalanche SOA**

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

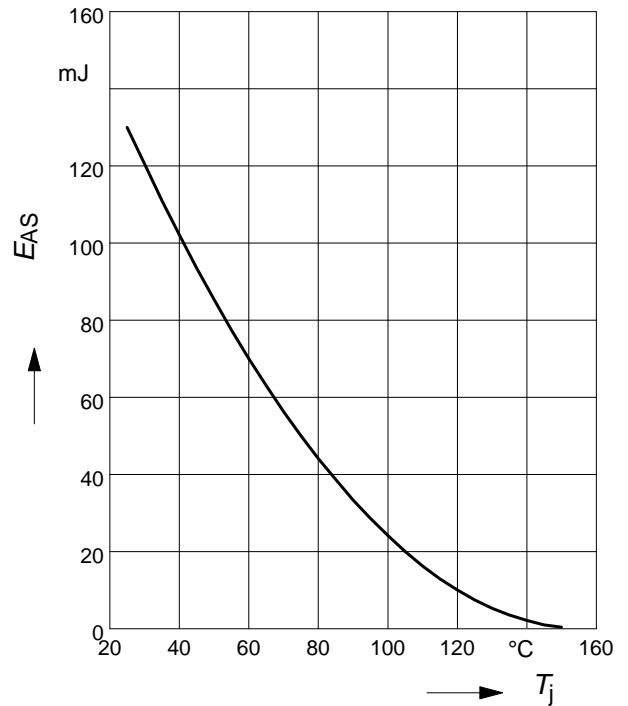
par.:  $T_j \leq 150\text{ }^\circ\text{C}$



**14 Avalanche energy**

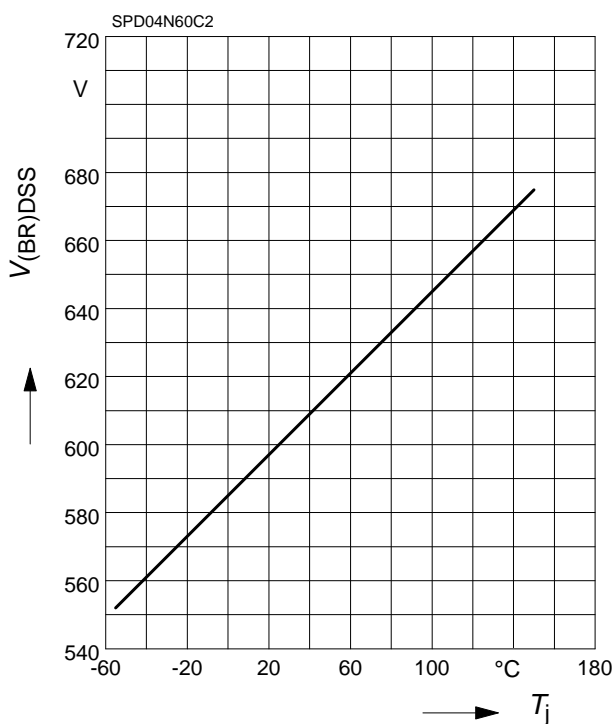
$$E_{AS} = f(T_j)$$

par.:  $I_D = 3.6\text{ A}$ ,  $V_{DD} = 50\text{ V}$



**15 Drain-source breakdown voltage**

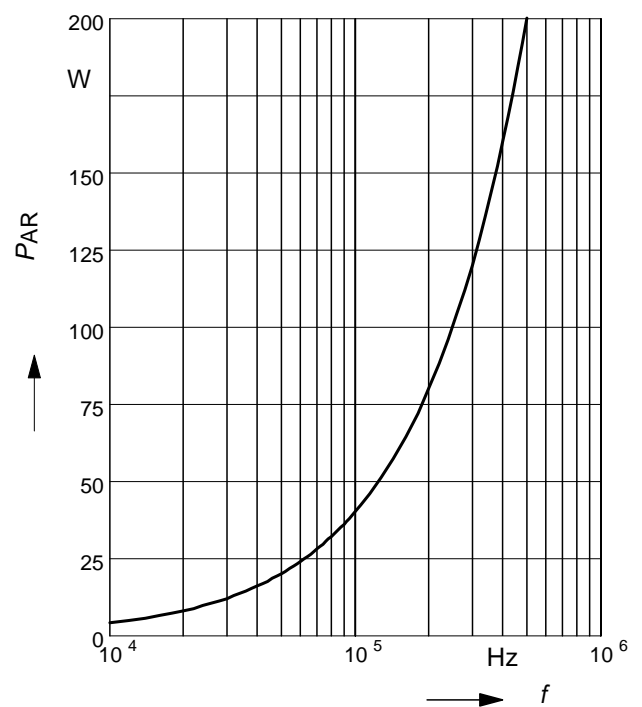
$$V_{(BR)DSS} = f(T_j)$$



**16 Avalanche power losses**

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

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

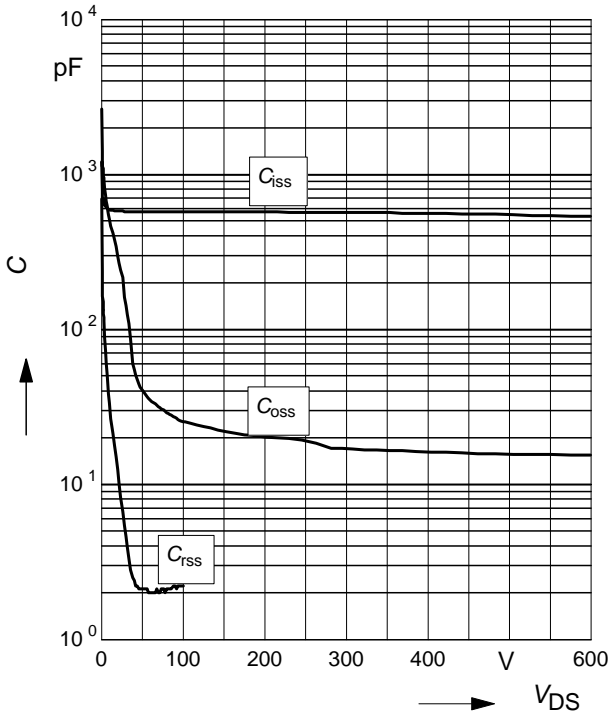




17 Typ. capacitances

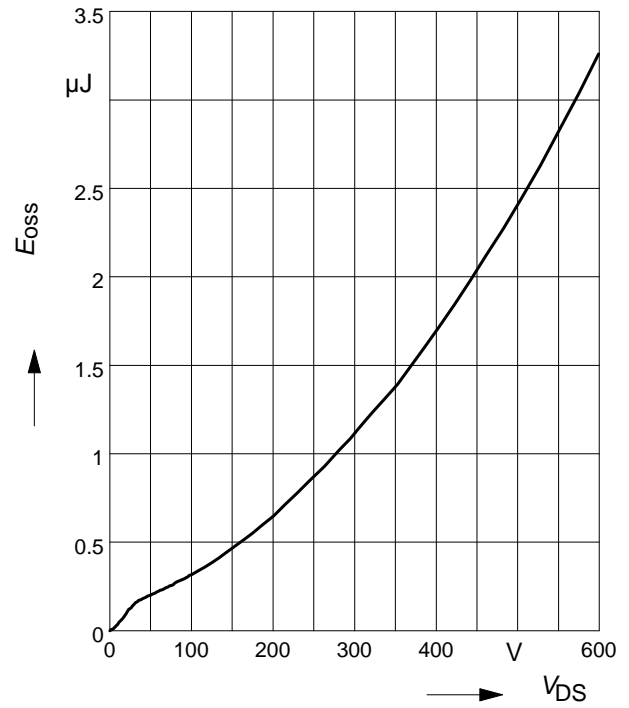
$$C = f(V_{DS})$$

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

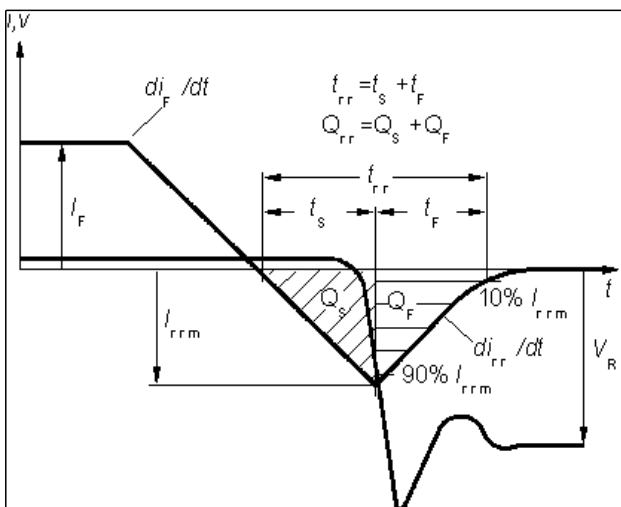


18 Typ.  $C_{oss}$  stored energy

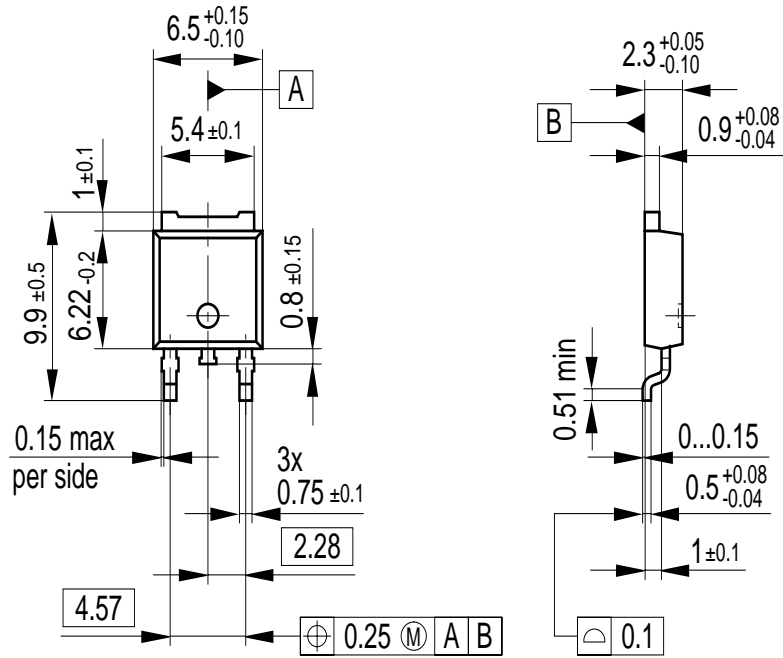
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics



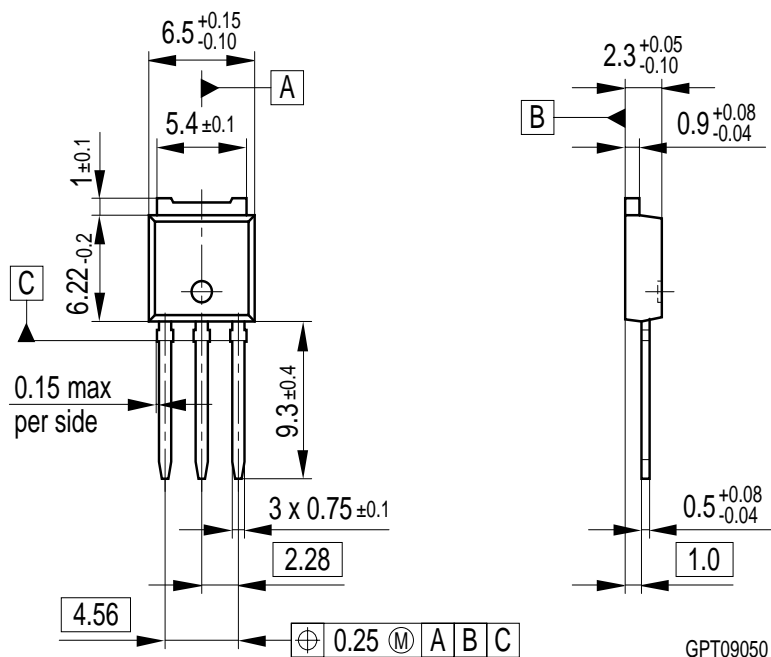
P-TO-252-3-1 (D-PAK)



GPT09051

All metal surfaces tin plated, except area of cut.

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



GPT09050

All metal surfaces tin plated, except area of cut.

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