

## Cool MOS™ Power Transistor

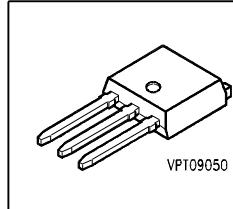
### Feature

- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances
- 150 °C operating temperature

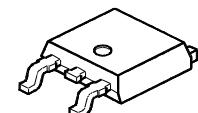
### Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	3	Ω
$I_D$	1.8	A

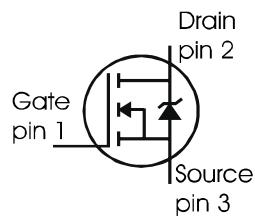
P-T0251



P-T0252



Type	Package	Ordering Code	Marking
SPD02N60C3	P-T0252	Q67040-S4420	02N60C3
SPU02N60C3	P-T0251	-	02N60C3



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

Parameter	Symbol	Value	Unit
Continuous drain current	$I_D$	1.8	A
$T_C = 25^\circ\text{C}$			
$T_C = 100^\circ\text{C}$			
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D \text{ puls}}$	5.4	mJ
Avalanche energy, single pulse	$E_{AS}$	50	
$I_D=0.9\text{A}$ , $V_{DD}=50\text{V}$		0.07	
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1)</sup>	$E_{AR}$		
$I_D=1.8\text{A}$ , $V_{DD}=50\text{V}$		1.8	A
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$		
Reverse diode dv/dt	dv/dt	6	V/ns
$I_S=1.8\text{A}$ , $V_{DS} < V_{DD}$ , $di/dt=100\text{A}/\mu\text{s}$ , $T_{jmax}=150^\circ\text{C}$		$\pm 20$	V
Gate source voltage static	$V_{GS}$		
Gate source voltage AC ( $f > 1\text{Hz}$ )	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25^\circ\text{C}$	$P_{tot}$	25	W
Operating and storage temperature	$T_j$ , $T_{stg}$	-55... +150	°C

**Thermal Characteristics**

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
<b>Characteristics</b>					
Thermal resistance, junction - case	$R_{\text{thJC}}$	-	-	5	K/W
Thermal resistance, junction - ambient, leaded	$R_{\text{thJA}}$	-	-	75	
SMD version, device on PCB: @ min. footprint @ 6 cm <sup>2</sup> cooling area <sup>2)</sup>	$R_{\text{thJA}}$	-	-	75	
Linear derating factor		-	-	0.2	W/K
Soldering temperature, 1.6 mm (0.063 in.) from case for 10s	$T_{\text{sold}}$	-	-	260	°C

**Electrical Characteristics**, at  $T_j = 25$  °C, unless otherwise specified

<b>Static Characteristics</b>					
Drain-source breakdown voltage $V_{GS}=0V, I_D=0.25mA$	$V_{(\text{BR})DSS}$	600	-	-	V
Drain-source avalanche breakdown voltage $V_{GS}=0V, I_D=0.25A$	$V_{(\text{BR})DS}$	-	700	-	
Gate threshold voltage, $V_{GS} = V_{DS}$ $I_D = 80 \mu A$	$V_{GS(\text{th})}$	2.1	3	3.9	
Zero gate voltage drain current $V_{DS} = 600 V, V_{GS} = 0 V, T_j = 25$ °C $V_{DS} = 600 V, V_{GS} = 0 V, T_j = 150$ °C	$I_{DSS}$	-	0.5	1	$\mu A$
-		-	-	50	
Gate-source leakage current $V_{GS}=30V, V_{DS}=0V$	$I_{GSS}$	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=1.1A, T_j=25^\circ C$ $V_{GS}=10V, I_D=1.1A, T_j=150^\circ C$	$R_{DS(\text{on})}$	-	2.7	3	$\Omega$
-		-	6	6.7	
Gate input resistance $f = 1$ MHz, open drain	$R_G$	-	9	-	

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

<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  $T_j = 25^\circ\text{C}$ , unless otherwise specified

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Transconductance	$g_{fs}$	$V_{DS} \geq 2 * I_D * R_{DS(on)max}$ $I_D = 1.1\text{A}$	-	1.75	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ , $f = 1\text{MHz}$	-	200	-	pF
Output capacitance	$C_{oss}$		-	90	-	
Reverse transfer capacitance	$C_{rss}$		-	4	-	
Effective output capacitance, 1) energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	8.1	-	pF
Effective output capacitance, 2) time related	$C_{o(tr)}$		-	15.7	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 350\text{V}$ , $V_{GS} = 0/10\text{V}$ , $I_D = 1.8\text{A}$ , $R_G = 25\Omega$	-	6	-	ns
Rise time	$t_r$		-	3	-	
Turn-off delay time	$t_{d(off)}$		-	68	70	
Fall time	$t_f$		-	12	30	

#### Gate Charge Characteristics

Gate to source charge	$Q_{gs}$	$V_{DD} = 420\text{V}$ , $I_D = 1.8\text{A}$	-	1.6	-	nC
Gate to drain charge	$Q_{gd}$		-	3.8	-	
Gate charge total	$Q_g$	$V_{DD} = 420\text{V}$ , $I_D = 1.8\text{A}$ , $V_{GS} = 0$ to $10\text{V}$		-	9.5	12.5
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 420\text{V}$ , $I_D = 1.8\text{A}$	-	5.5	-	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%  $V_{DSS}$ .

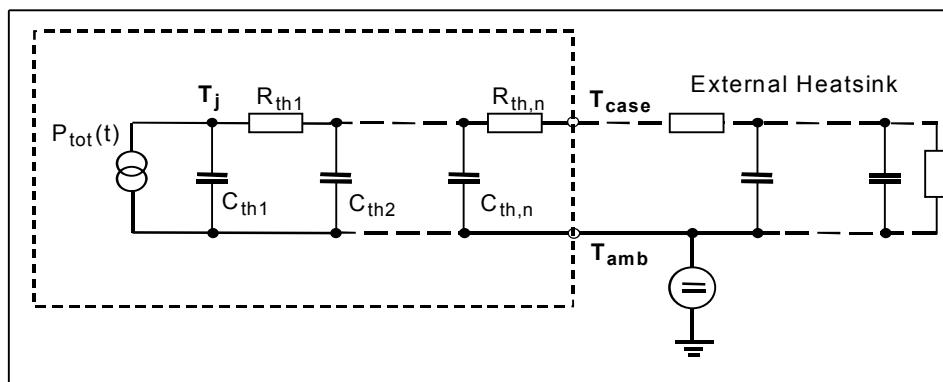
<sup>2</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Inverse diode continuous forward current	$I_S$	$T_C=25^\circ\text{C}$	-	-	1.8	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	5.4	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=420\text{V}, I_F=I_S, di_F/dt=100\text{A}/\mu\text{s}$	-	200	350	ns
Reverse recovery charge	$Q_{rr}$		-	1.3	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	9	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	-	200	$\text{A}/\mu\text{s}$

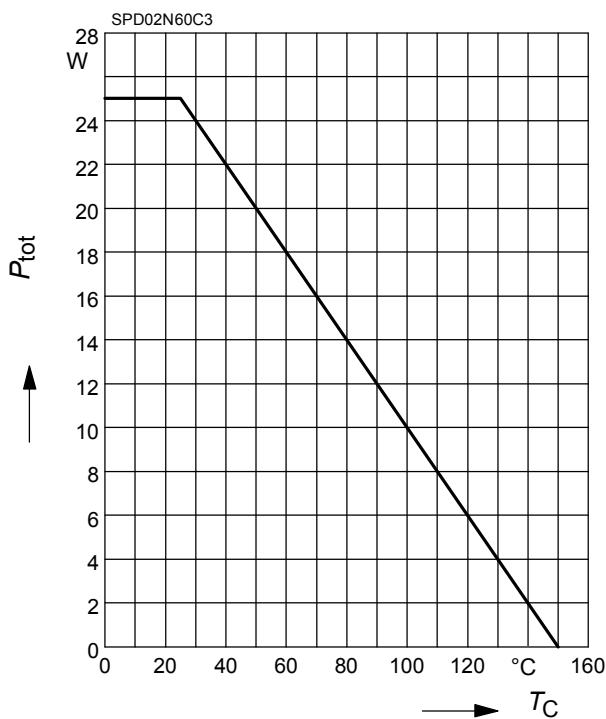
**Transient Thermal Characteristics**

Symbol	Value	Unit	Symbol	Value	Unit
Thermal resistance			Thermal capacitance		
$R_{th1}$	0.101	K/W	$C_{th1}$	0.00003158	Ws/K
$R_{th2}$	0.207		$C_{th2}$	0.0001104	
$R_{th3}$	0.311		$C_{th3}$	0.0002001	
$R_{th4}$	0.583		$C_{th4}$	0.0004898	
$R_{th5}$	0.501		$C_{th5}$	0.00274	
$R_{th6}$	0.135		$C_{th6}$	0.035	



### 1 Power dissipation

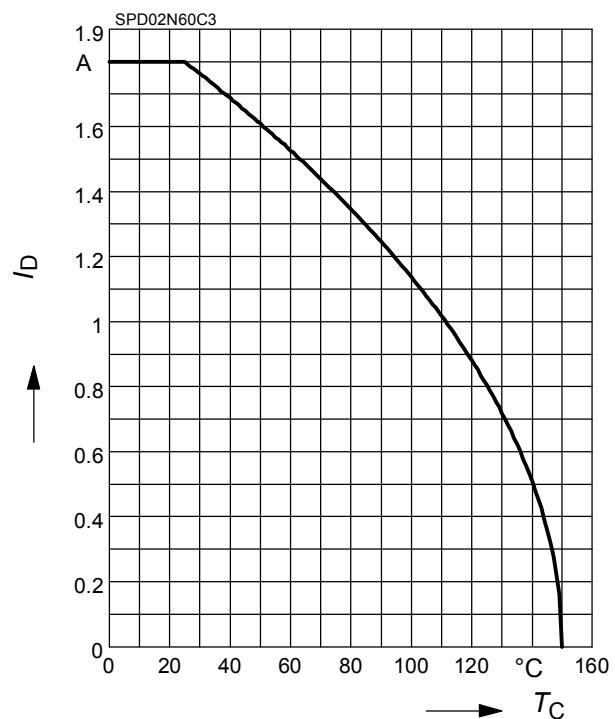
$$P_{\text{tot}} = f(T_C)$$



### 2 Drain current

$$I_D = f(T_C)$$

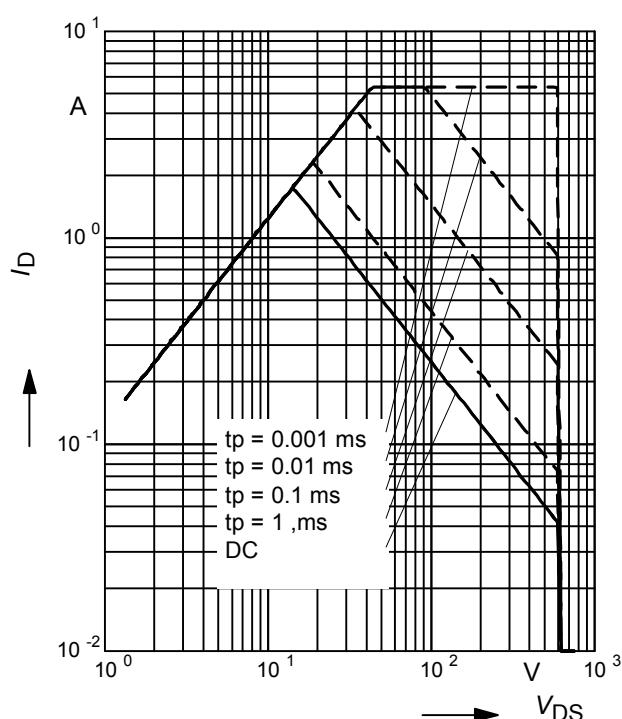
parameter:  $V_{GS} \geq 10 \text{ V}$



### 3 Safe operating area

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

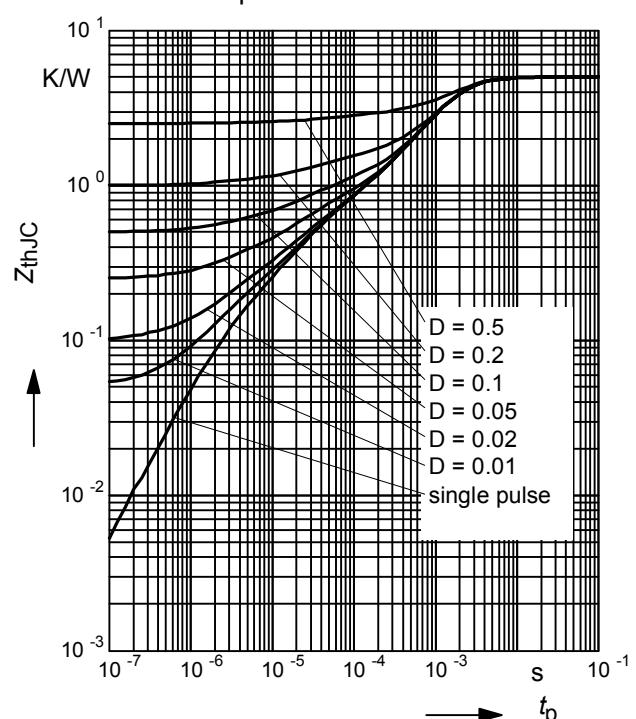
parameter :  $D = 0$  ,  $T_C=25^\circ\text{C}$



### 4 Transient thermal impedance

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

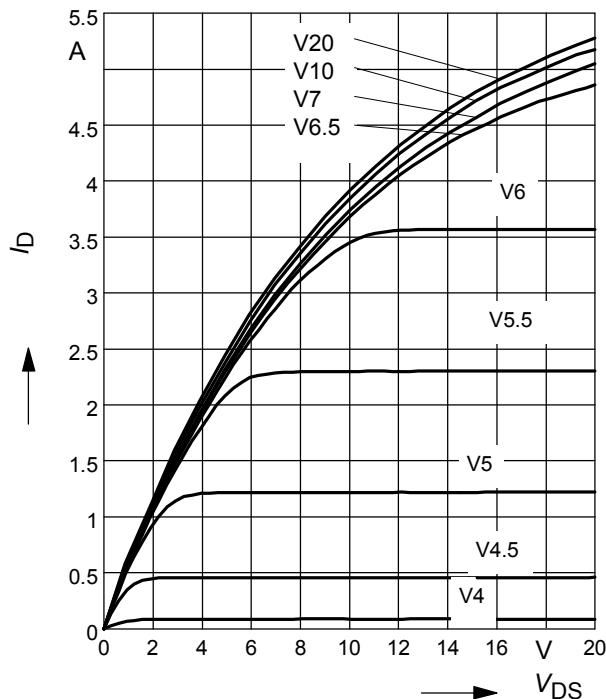
parameter:  $D = t_p/T$



### 5 Typ. output characteristic

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

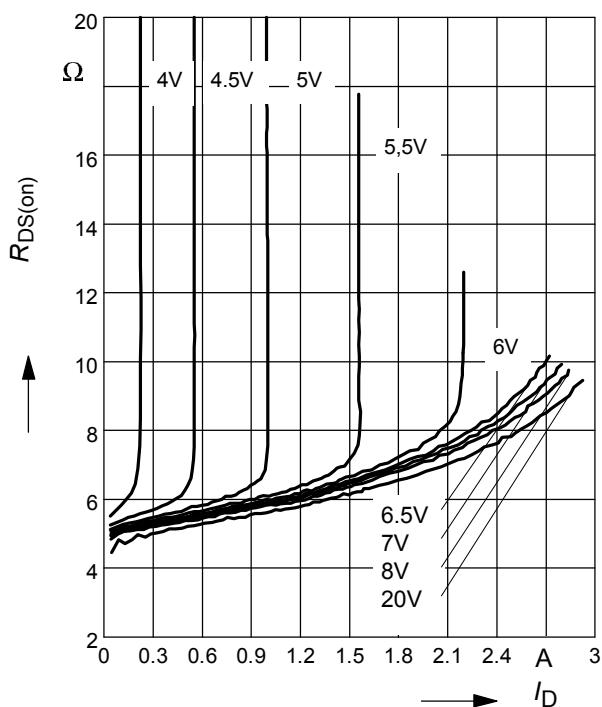
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



### 7 Typ. drain-source on resistance

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

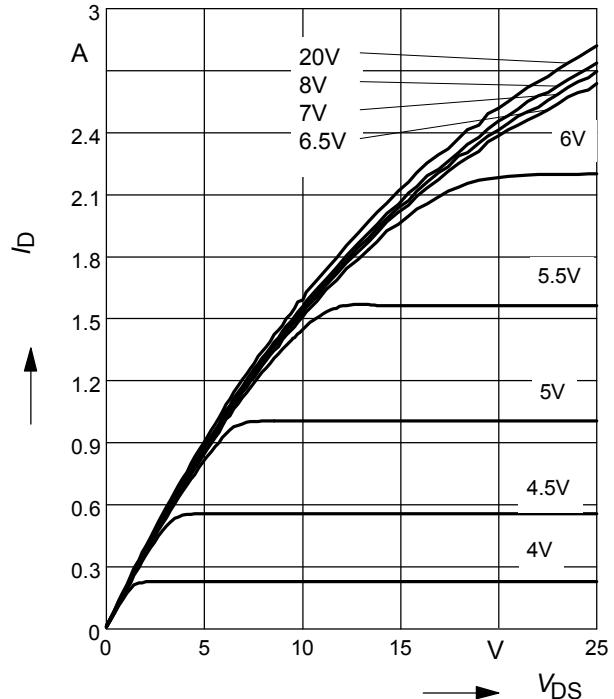
parameter:  $T_j=150^\circ\text{C}$ ,  $V_{GS}$



### 6 Typ. output characteristic

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

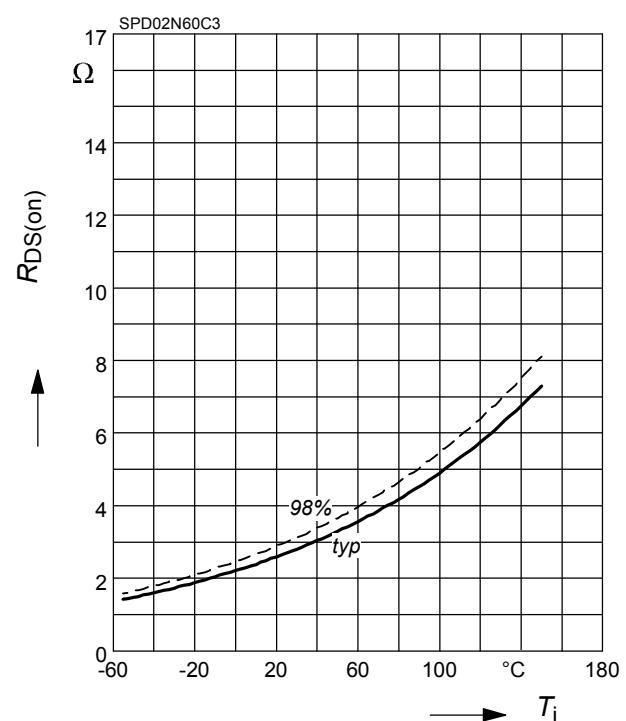
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



### 8 Drain-source on-state resistance

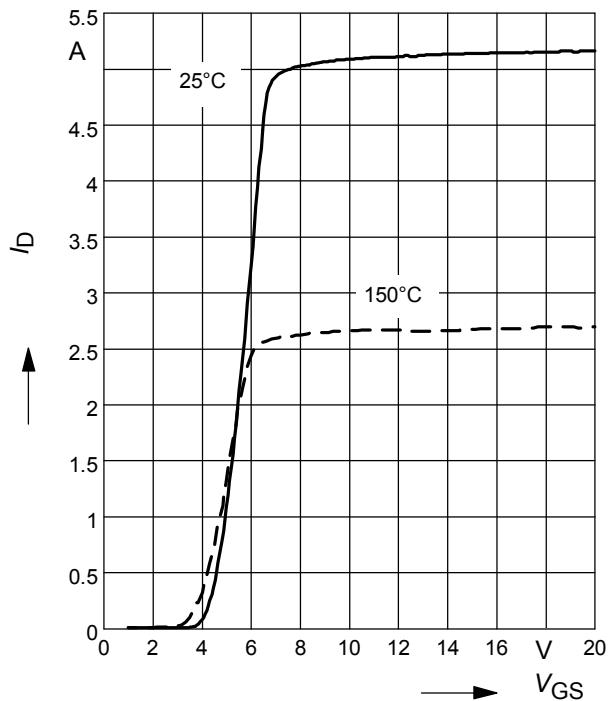
$R_{DS(on)} = f(T_j)$

parameter :  $I_D = 1.1 \text{ A}$ ,  $V_{GS} = 10 \text{ V}$



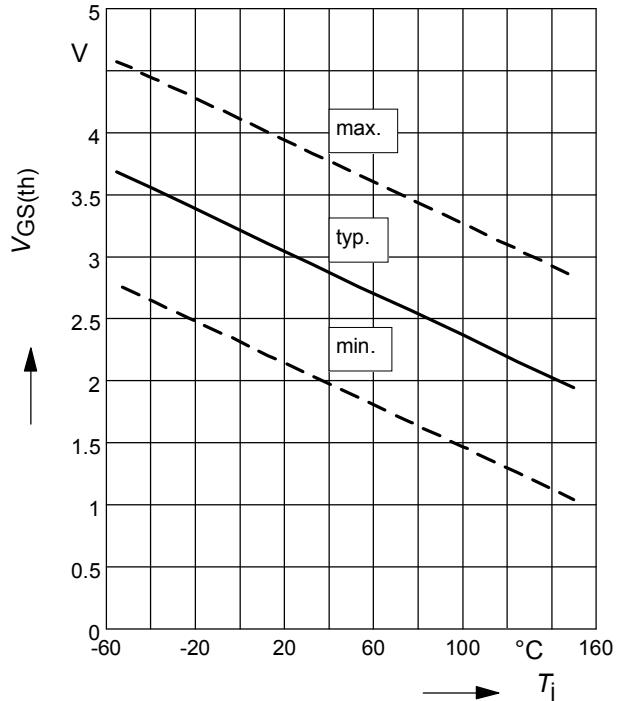
### 9 Typ. transfer characteristics

$I_D = f(V_{GS})$ ;  $V_{DS} \geq 2 \times I_D \times R_{DS(on)\max}$   
parameter:  $t_p = 10 \mu\text{s}$



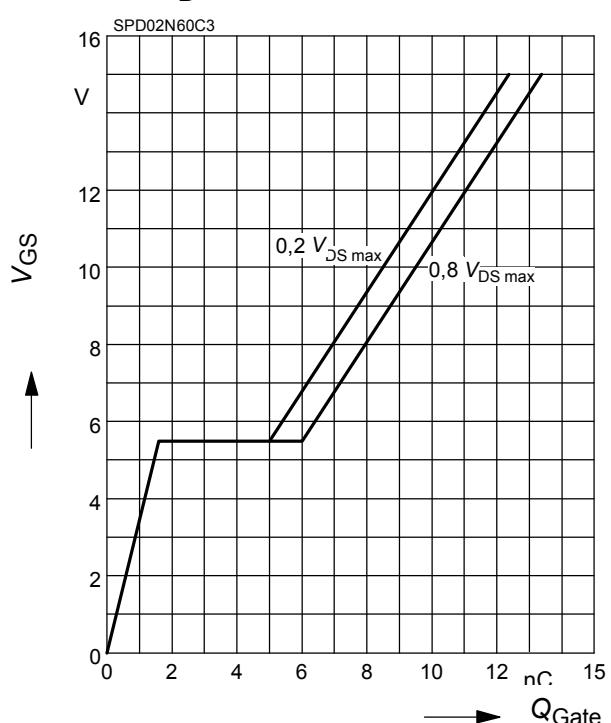
### 10 Gate threshold voltage

$V_{GS(\text{th})} = f(T_j)$   
parameter:  $V_{GS} = V_{DS}$ ,  $I_D = 80 \mu\text{A}$



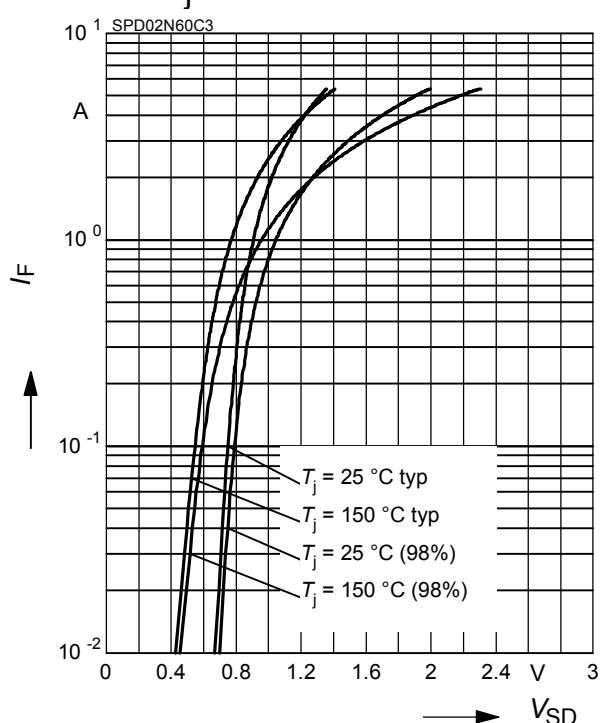
### 11 Typ. gate charge

$V_{GS} = f(Q_{\text{Gate}})$   
parameter:  $I_D = 1.8 \text{ A pulsed}$



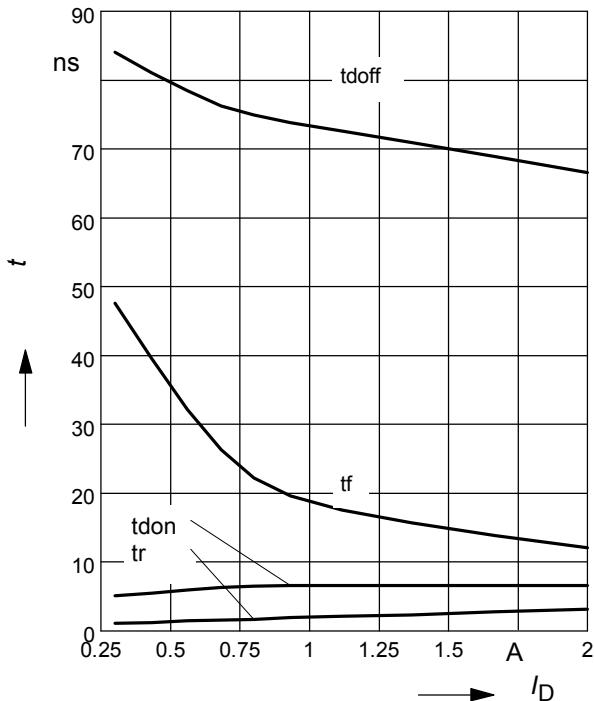
### 12 Forward characteristics of body diode

$I_F = f(V_{SD})$   
parameter:  $T_j$ ,  $t_p = 10 \mu\text{s}$



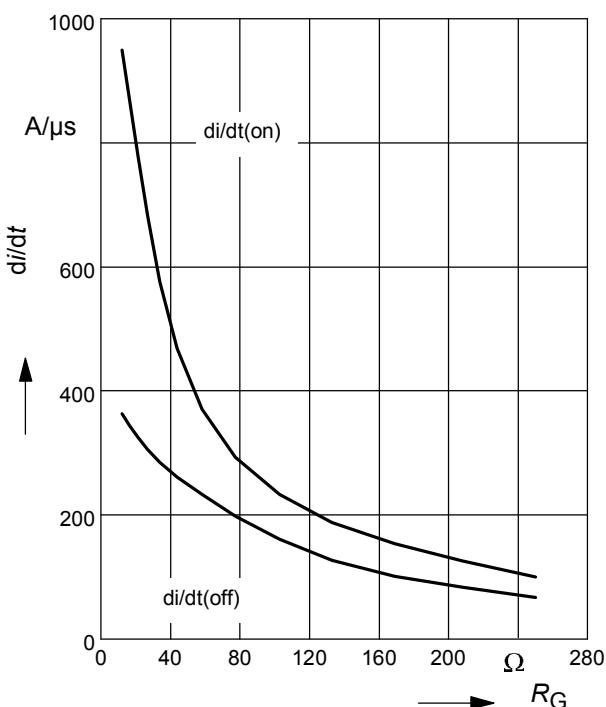
### 13 Typ. switching time

$t = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 25\Omega$



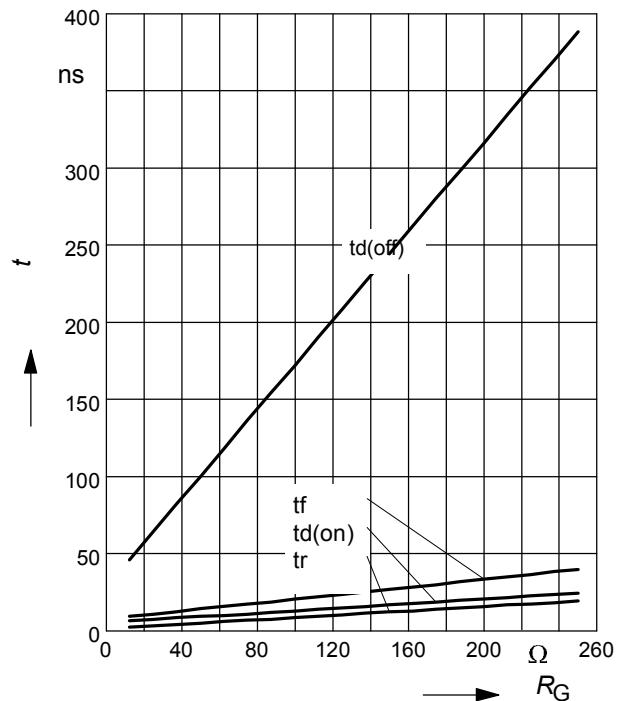
### 15 Typ. drain current slope

$di/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 1.8\text{A}$



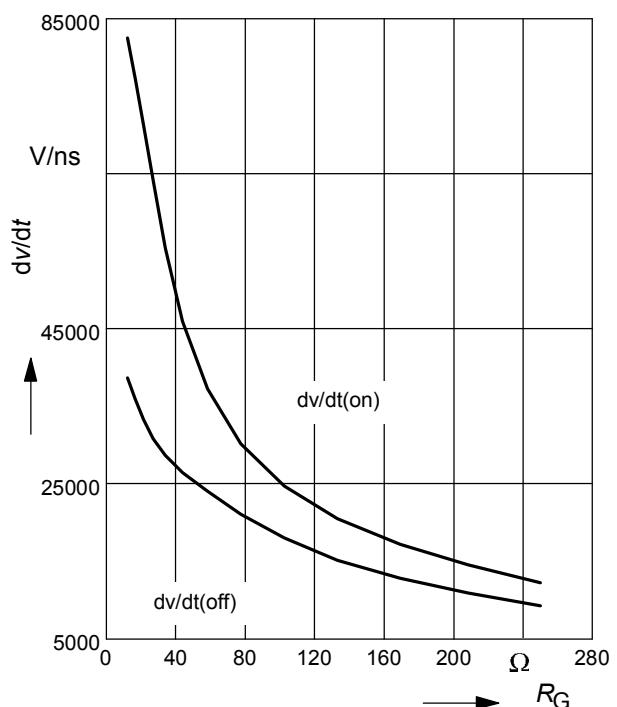
### 14 Typ. switching time

$t = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 1.8\text{A}$



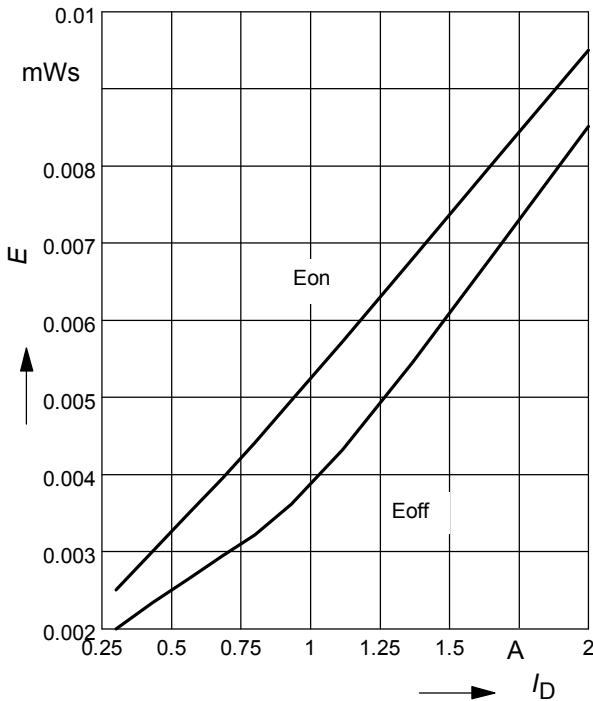
### 16 Typ. drain source voltage slope

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 1.8\text{A}$

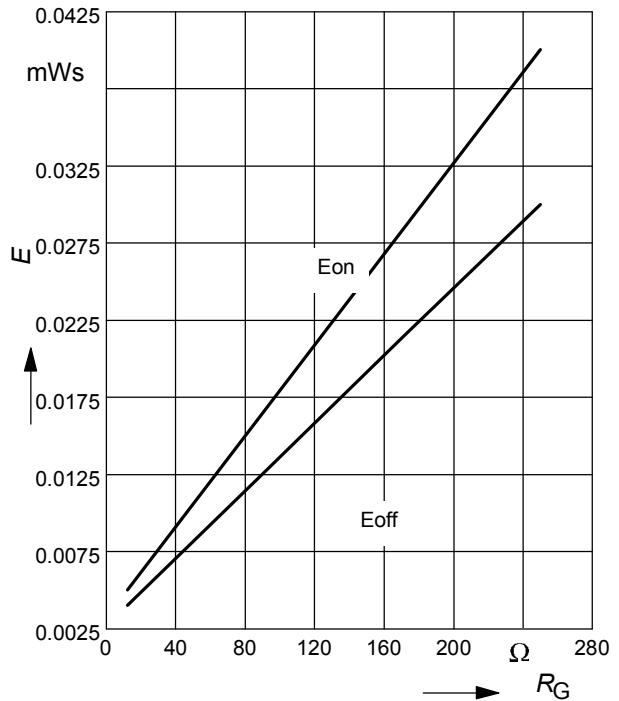


**17 Typ. switching losses**

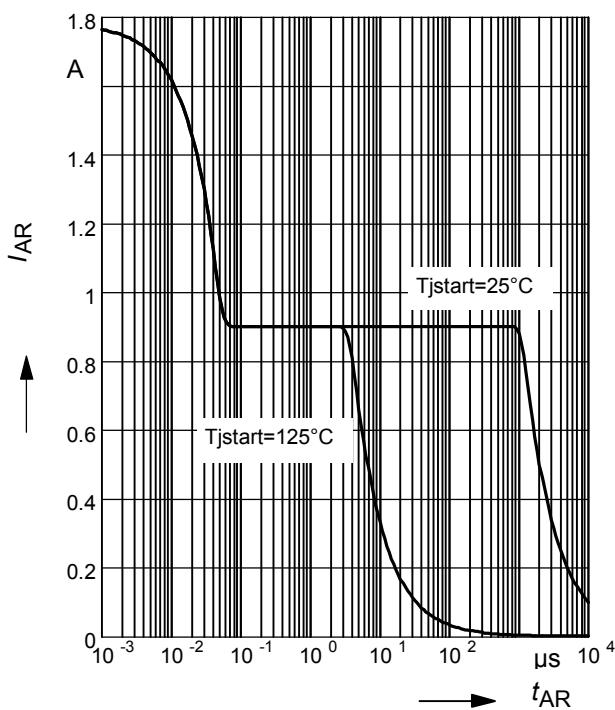
$E = f(I_D)$ , inductive load,  $T_j=125^\circ\text{C}$   
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=25\Omega$


**18 Typ. switching losses**

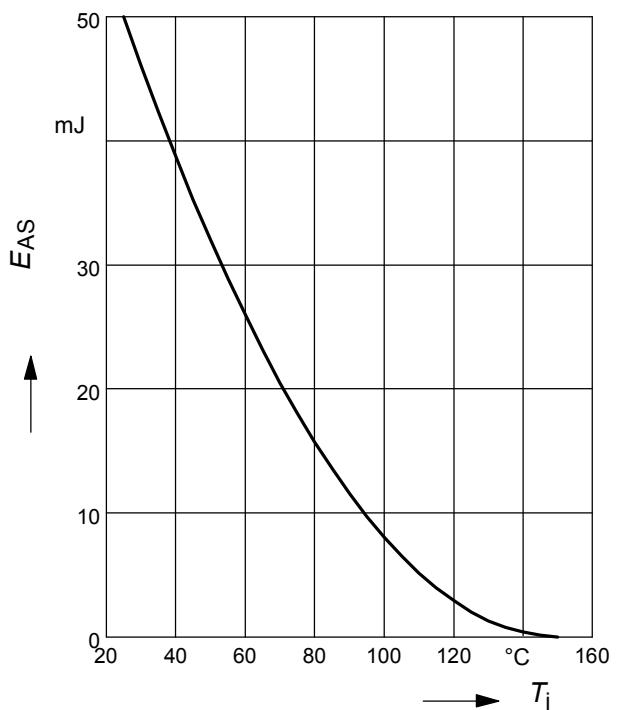
$E = f(R_G)$ , inductive load,  $T_j=125^\circ\text{C}$   
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=1.8\text{A}$


**19 Avalanche SOA**

$I_{AR} = f(t_{AR})$   
par.:  $T_j \leq 150^\circ\text{C}$

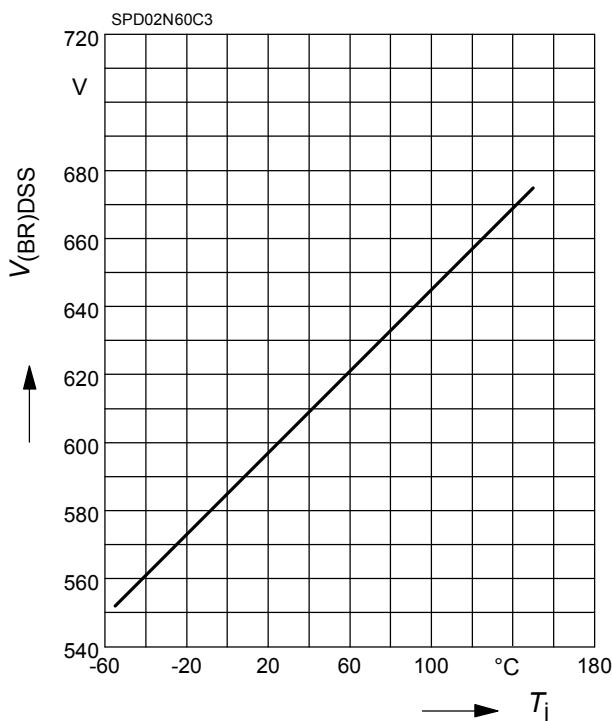

**20 Avalanche energy**

$E_{AS} = f(T_j)$   
par.:  $I_D = 0.9\text{ A}$ ,  $V_{DD} = 50\text{ V}$



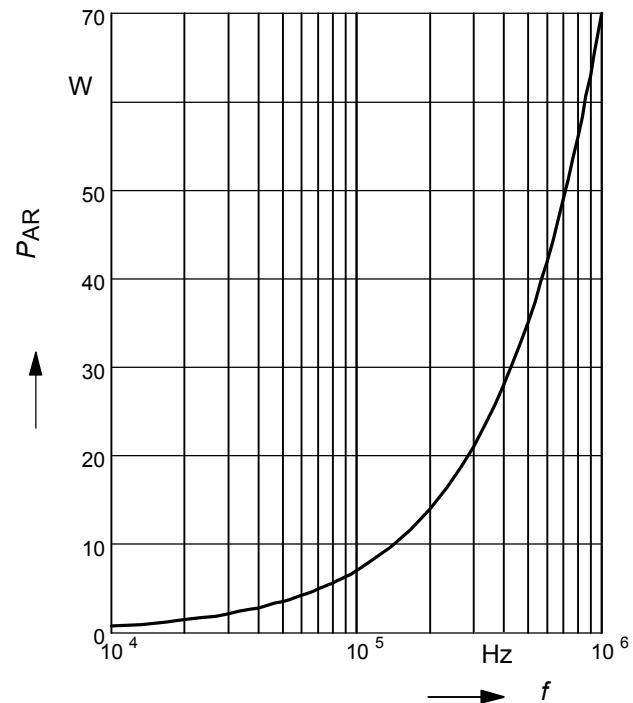
**21 Drain-source breakdown voltage**

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


**22 Avalanche power losses**

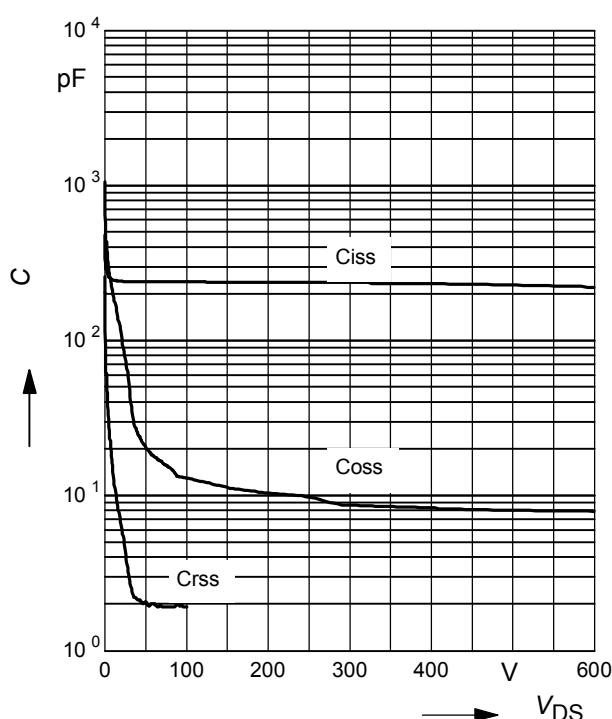
$$P_{AR} = f(f)$$

parameter:  $E_{AR}=0.07\text{mJ}$

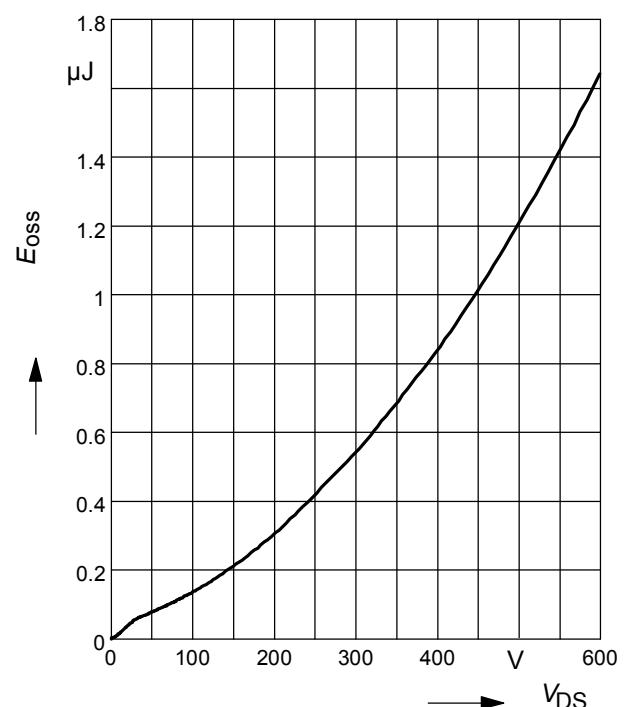

**23 Typ. capacitances**

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

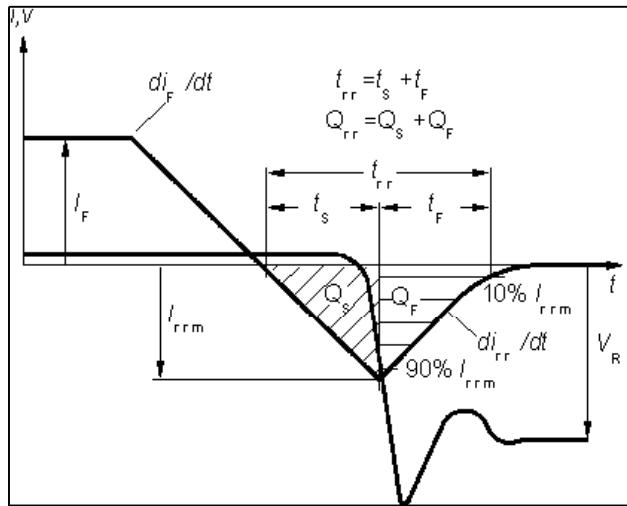
parameter:  $V_{GS}=0\text{V}$ ,  $f=1\text{MHz}$

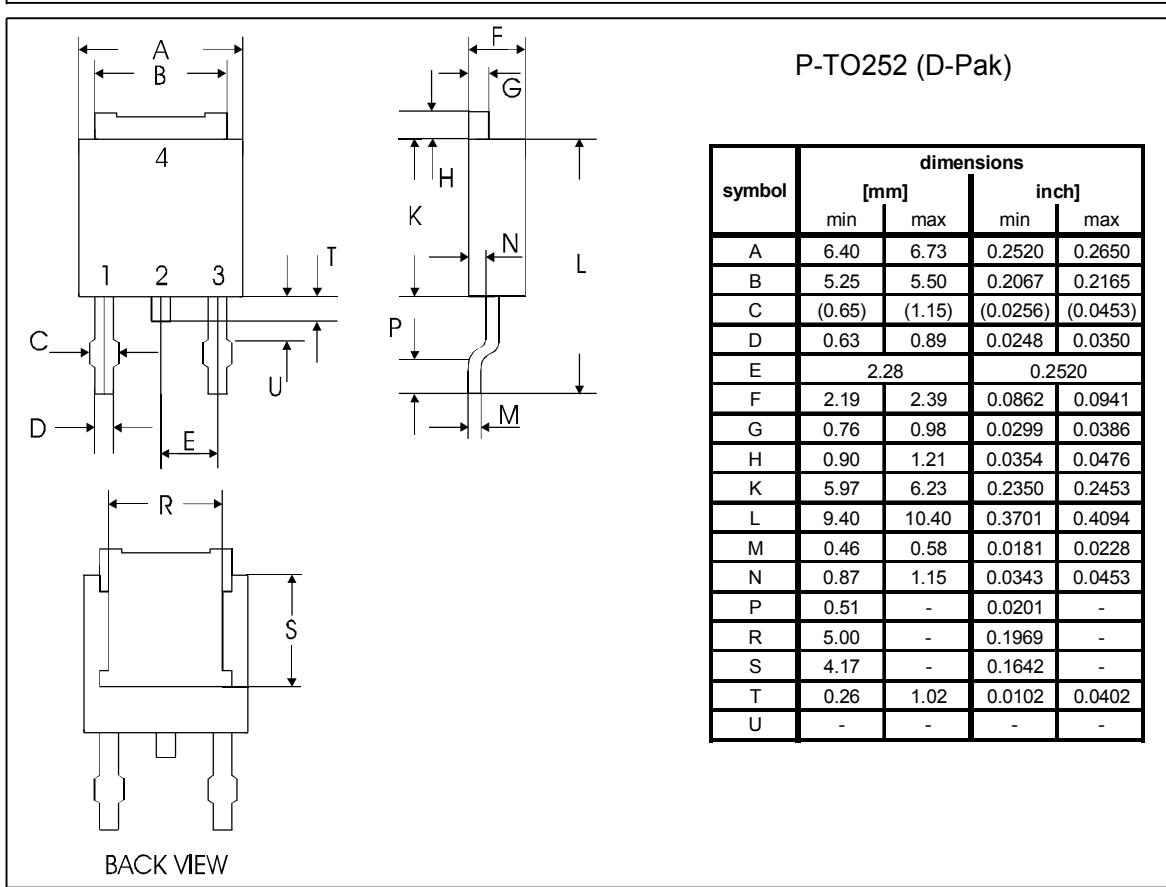
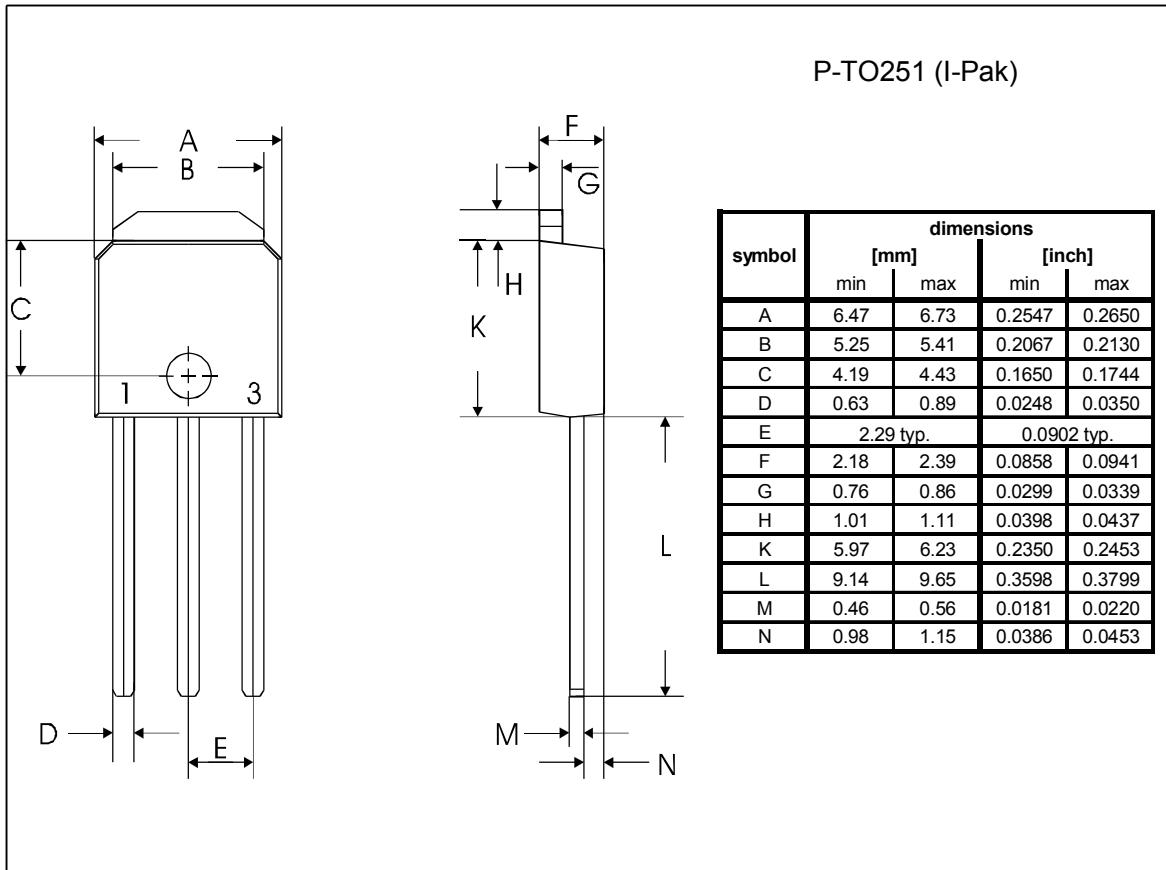

**24 Typ.  $C_{oss}$  stored energy**

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



### Definition of diodes switching characteristics





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