

## Cool MOS™ Power Transistor



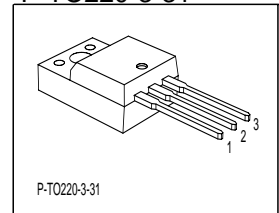
### Feature

- 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

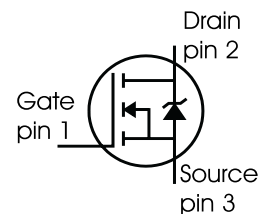
### Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.19	$\Omega$
$I_D$	8.1	A

P-TO220-3-31



Type	Package	Ordering Code	Marking
SPA20N60C3	P-TO220-3-31	Q67040-S4410	20N60C3



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

Parameter	Symbol	Value	Unit
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	$I_D$	8.1 5.1	A
Pulsed drain current, $t_p$ limited by $T_{jmax}$	$I_{D\text{ puls}}$	62.1	
Avalanche energy, single pulse $I_D=10\text{A}$ , $V_{DD}=50\text{V}$	$E_{AS}$	690	mJ
Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1)</sup> $I_D=20\text{A}$ , $V_{DD}=50\text{V}$	$E_{AR}$	1	
Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$	$I_{AR}$	20	A
Reverse diode $dv/dt$ $I_S=8.1\text{A}$ , $V_{DS} < V_{DD}$ , $di/dt=100\text{A}/\mu\text{s}$ , $T_{jmax}=150\text{°C}$	$dv/dt$	6	V/ns
Gate source voltage static	$V_{GS}$	$\pm 20$	V
Gate source voltage dynamic	$V_{GS}$	$\pm 30$	
Power dissipation, $T_C = 25\text{°C}$	$P_{tot}$	34.5	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	$R_{thJC}$	-	-	3.6	K/W
Thermal resistance, junction - ambient, leaded	$R_{thJA}$	-	-	80	
Linear derating factor		-	-	0.28	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 $V_{GS}=0V, I_D=20A$	$V_{(BR)DS}$	-	700	-	
Gate threshold voltage, $V_{GS} = V_{DS}$ $I_D = 1\text{ mA}$	$V_{GS(th)}$	2.1	3	3.9	
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	25	μA
		-	-	250	
Gate-source leakage current $V_{GS}=20V, V_{DS}=0V$	$I_{GSS}$	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=5.1A, T_j=25\text{ °C}$ $V_{GS}=10V, I_D=5.1A, T_j=150\text{ °C}$	$R_{DS(on)}$	-	0.16	0.19	Ω
		-	0.54	0.64	
Gate input resistance $f = 1\text{ MHz}$ , open drain	$R_G$	-	0.54	-	

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

**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	$g_{fs}$	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ , $I_D = 5.1\text{A}$	-	17.5	-	S
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,	-	3000	-	pF
Output capacitance	$C_{oss}$	$f = 1\text{MHz}$	-	1170	-	
Reverse transfer capacitance	$C_{rss}$		-	40	-	
Effective output capacitance, 1) energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$	-	83	-	pF
Effective output capacitance, 2) time related	$C_{o(tr)}$		-	160	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380\text{V}$ , $V_{GS} = 0/13\text{V}$ , $I_D = 8.1\text{A}$ , $R_G = 3.6\Omega$ , $T_j = 125$	-	10	-	ns
Rise time	$t_r$	$V_{DD} = 380\text{V}$ , $V_{GS} = 0/13\text{V}$ ,	-	5	-	
Turn-off delay time	$t_{d(off)}$	$I_D = 8.1\text{A}$ , $R_G = 3.6\Omega$	-	67	100	
Fall time	$t_f$		-	4.5	12	

**Gate Charge Characteristics**

Gate to source charge	$Q_{gs}$	$V_{DD} = 480\text{V}$ , $I_D = 8.1\text{A}$	-	11	-	nC
Gate to drain charge	$Q_{gd}$		-	33	-	
Gate charge total	$Q_g$	$V_{DD} = 480\text{V}$ , $I_D = 8.1\text{A}$ , $V_{GS} = 0\text{ to } 10\text{V}$	-	87	114	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480\text{V}$ , $I_D = 8.1\text{A}$	-	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%  $V_{DSS}$ .

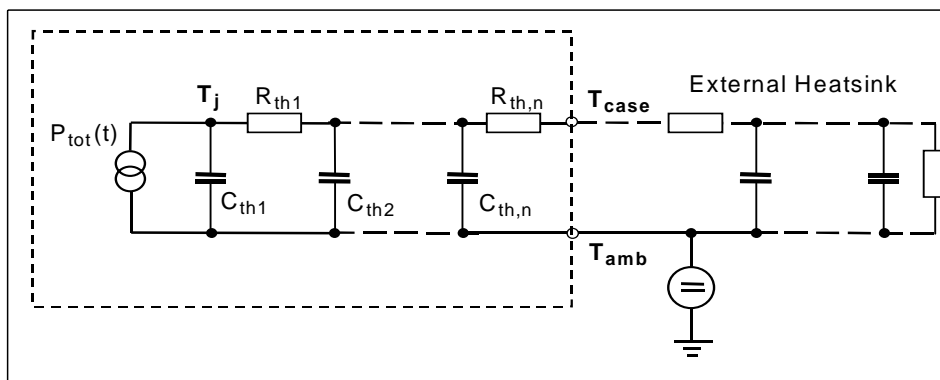
<sup>2</sup> $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
<b>Characteristics</b>						
Inverse diode continuous forward current	$I_S$	$T_C=25^\circ\text{C}$	-	-	8.1	A
Inverse diode direct current, pulsed	$I_{SM}$		-	-	62.1	
Inverse diode forward voltage	$V_{SD}$	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	$t_{rr}$	$V_R=480\text{V}, I_F=I_S,$	-	500	800	ns
Reverse recovery charge	$Q_{rr}$	$di_F/dt=100\text{A}/\mu\text{s}$	-	11	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rrm}$		-	70	-	A
Peak rate of fall of reverse recovery current	$di_{rr}/dt$		-	1400	-	$\text{A}/\mu\text{s}$

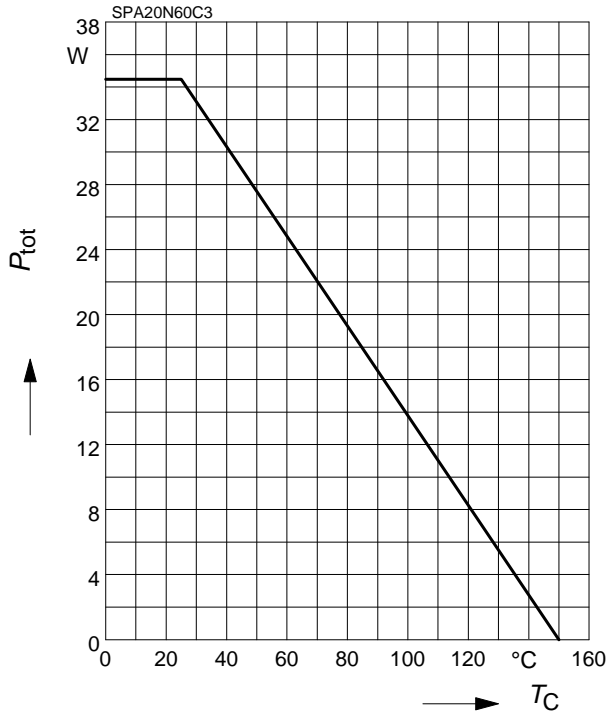
Transient Thermal Characteristics

Symbol	Value	Unit	Symbol	Value	Unit
	typ.			typ.	
Thermal resistance			Thermal capacitance		
$R_{th1}$	0.0077	K/W	$C_{th1}$	0.000376	Ws/K
$R_{th2}$	0.015		$C_{th2}$	0.00141	
$R_{th3}$	0.022		$C_{th3}$	0.00192	
$R_{th4}$	0.063		$C_{th4}$	0.00332	
$R_{th5}$	0.214		$C_{th5}$	0.019	
$R_{th6}$	2.479		$C_{th6}$	0.412	



### 1 Power dissipation

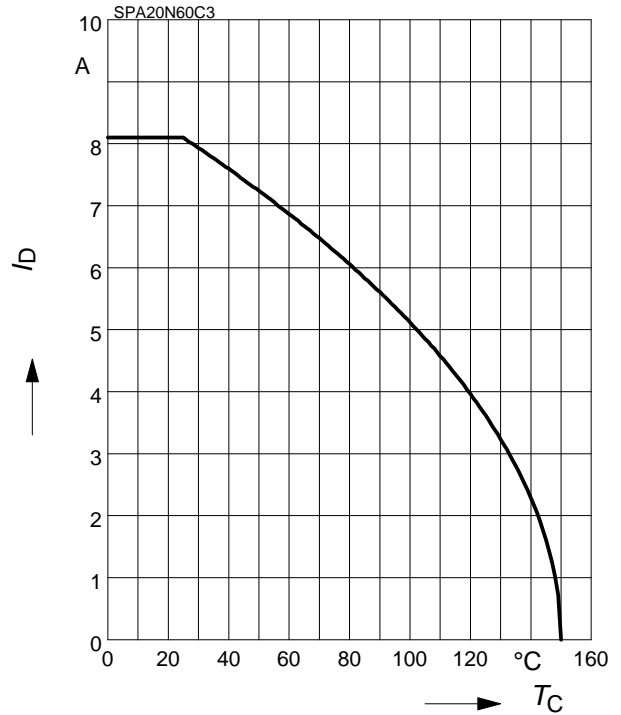
$$P_{tot} = f(T_C)$$



### 2 Drain current

$$I_D = f(T_C)$$

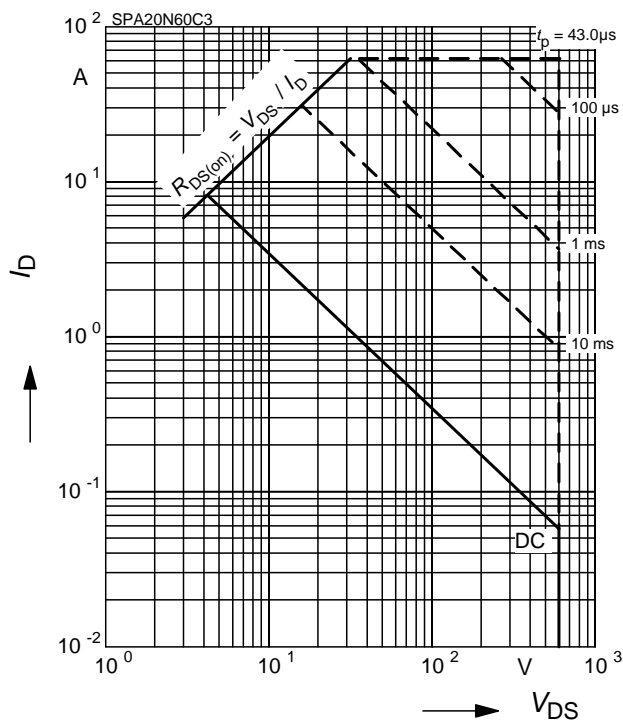
parameter:  $V_{GS} \geq 10\text{ V}$



### 3 Safe operating area

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

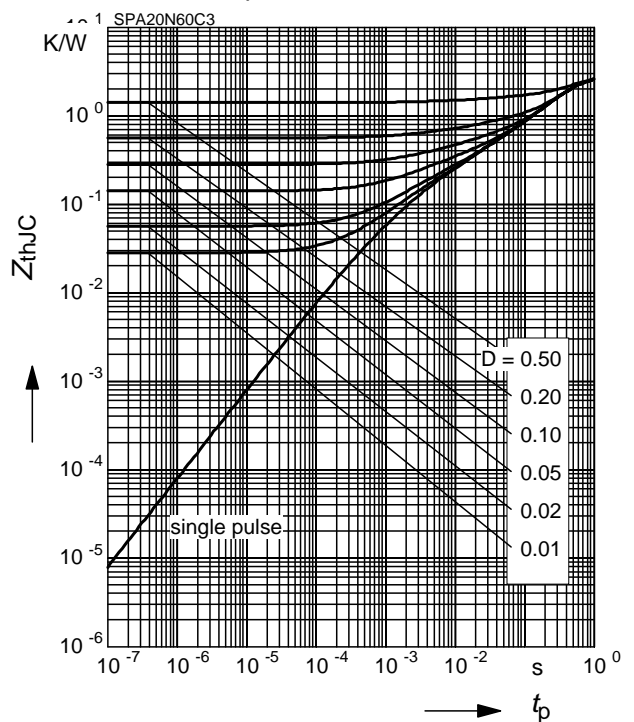
parameter:  $D = 0$ ,  $T_C = 25^\circ\text{C}$



### 4 Transient thermal impedance

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

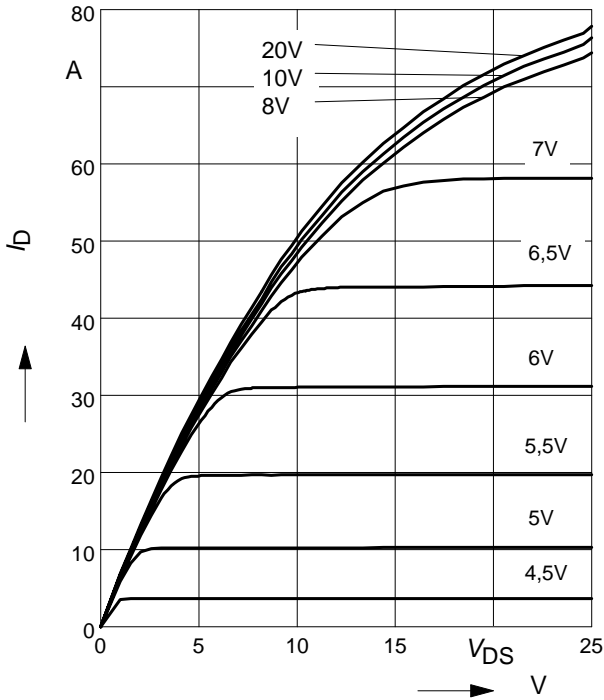
parameter:  $D = t_p/T$



**5 Typ. output characteristic**

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

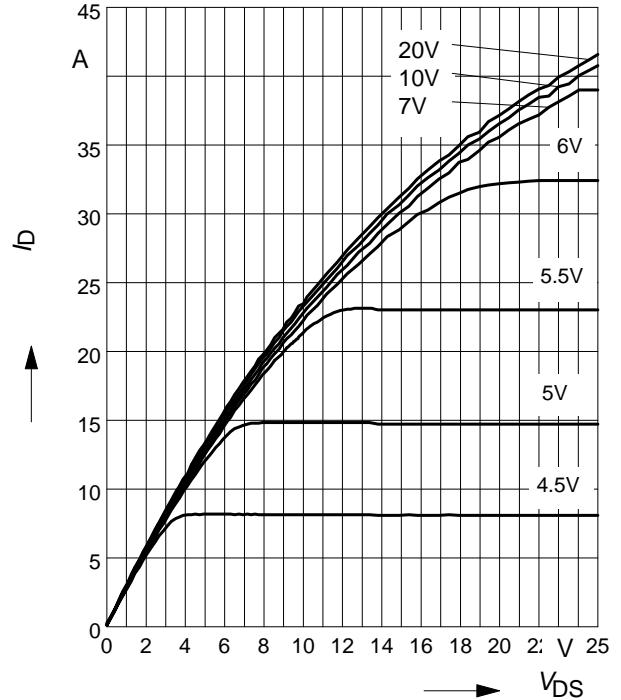
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



**6 Typ. output characteristic**

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

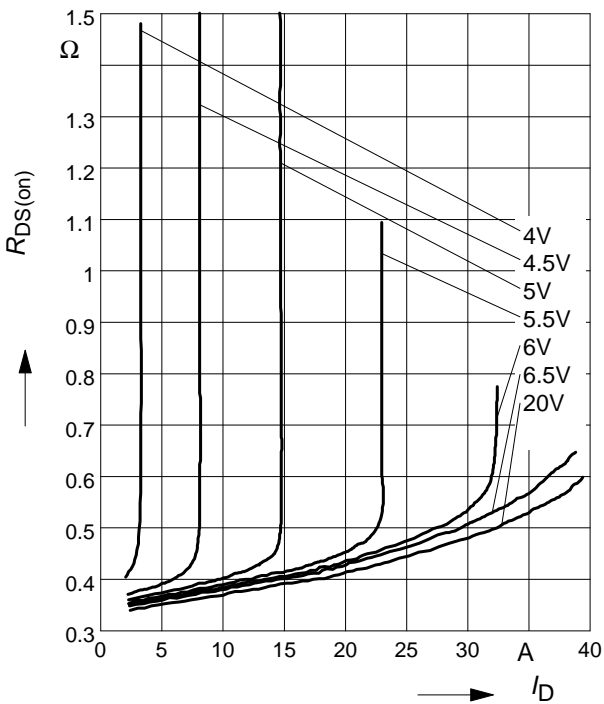
parameter:  $t_p = 10 \mu\text{s}, V_{GS}$



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

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

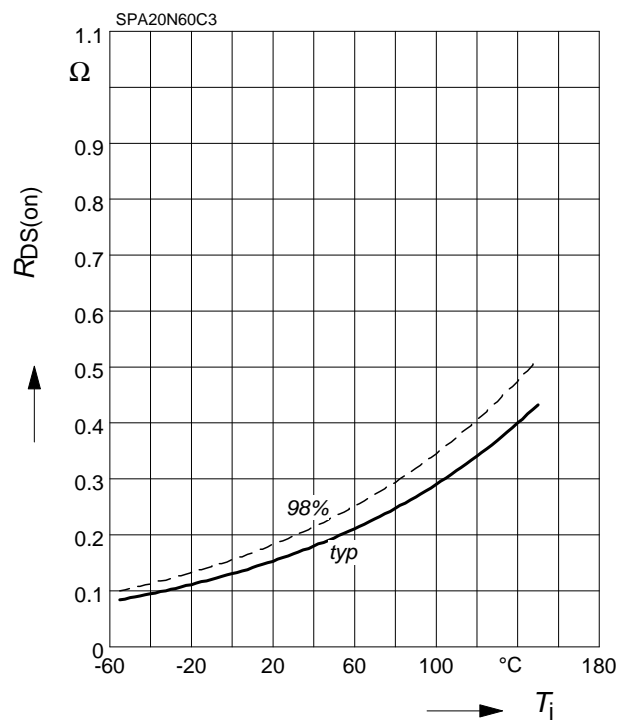
parameter:  $T_j = 150^\circ\text{C}, V_{GS}$



**8 Drain-source on-state resistance**

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

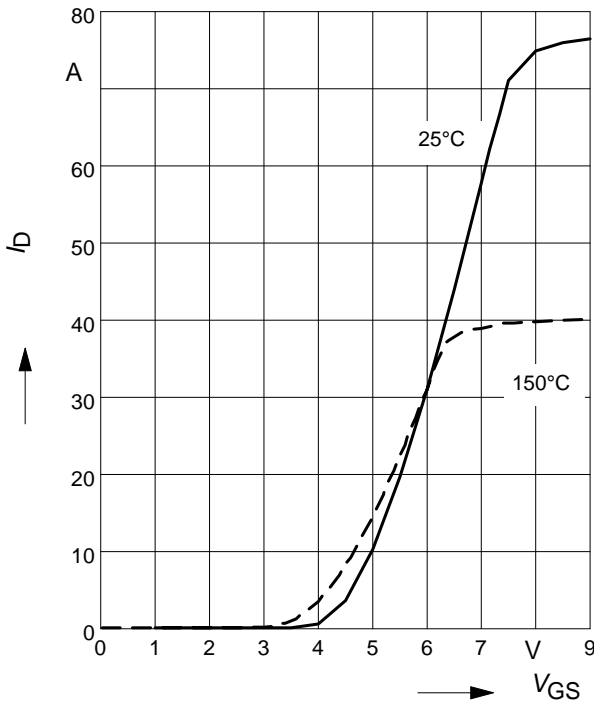
parameter:  $I_D = 5.1 \text{ A}, V_{GS} = 10 \text{ V}$



**9 Typ. transfer characteristics**

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

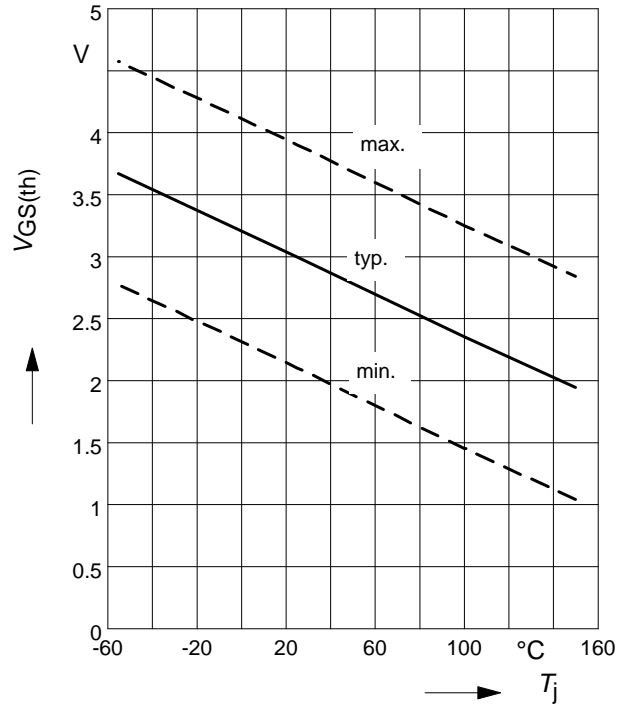
parameter:  $t_p = 10 \mu s$



**10 Gate threshold voltage**

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

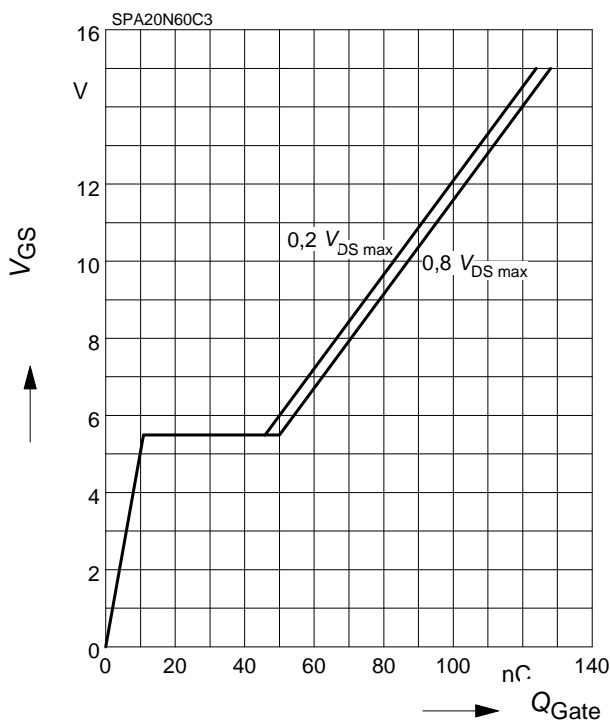
parameter:  $V_{GS} = V_{DS}$ ,  $I_D = 1 \text{ mA}$



**11 Typ. gate charge**

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

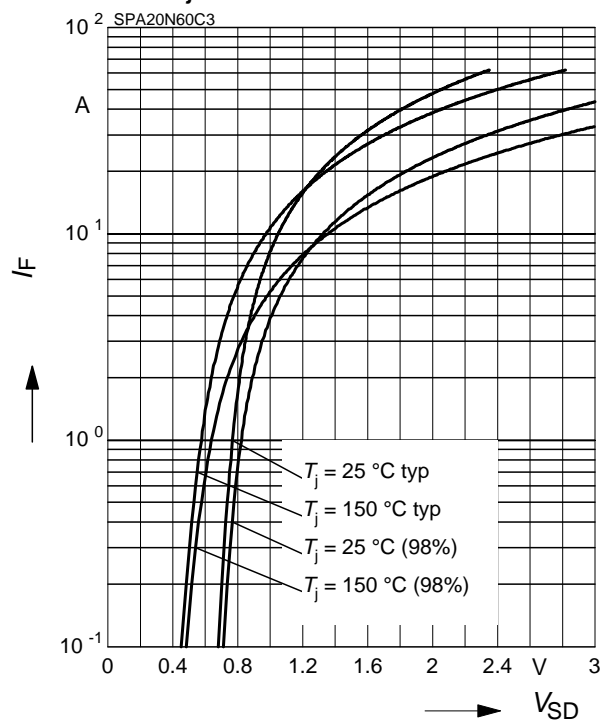
parameter:  $I_D = 8.1 \text{ A pulsed}$



**12 Forward characteristics of body diode**

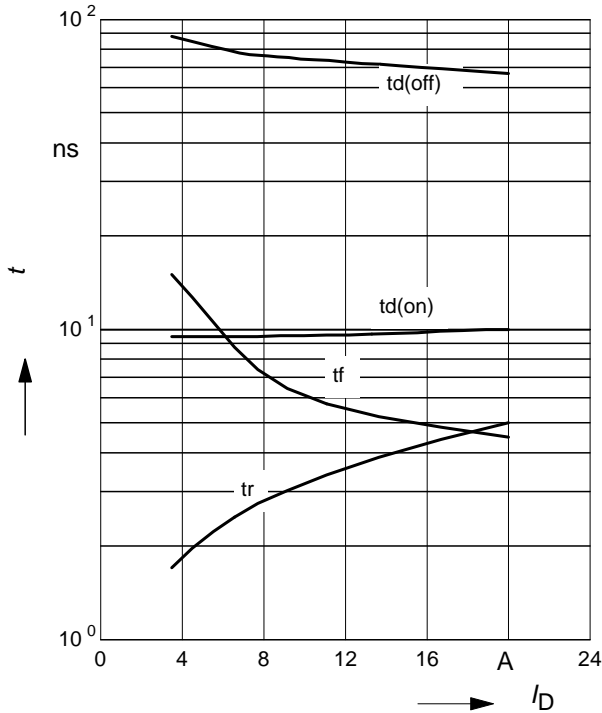
$I_F = f(V_{SD})$

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



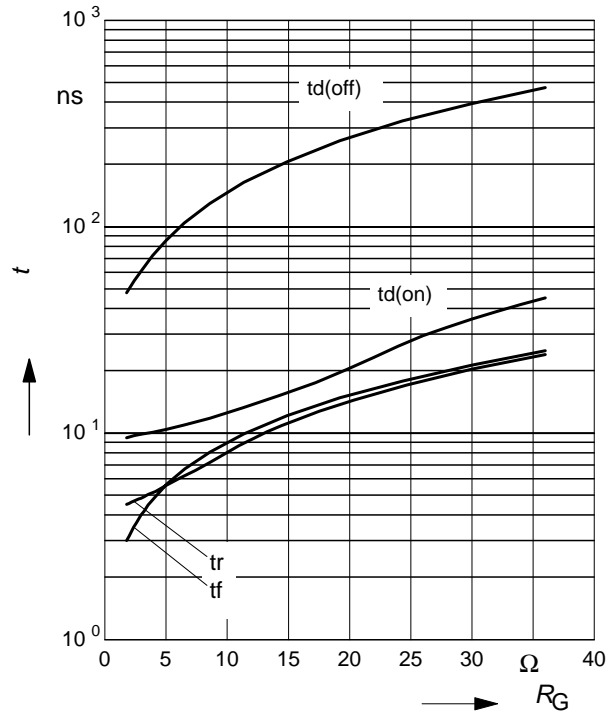
**3.6 Typ. switching time**

$t = f(I_D)$ , inductive load,  $T_j=125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $R_G=3.6\Omega$



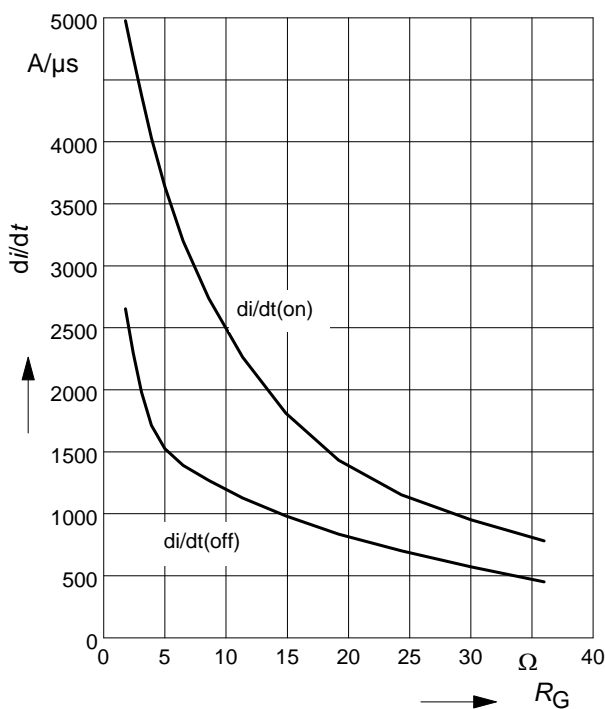
**13 Typ. switching time**

$t = f(R_G)$ , inductive load,  $T_j=125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=8.1\text{A}$



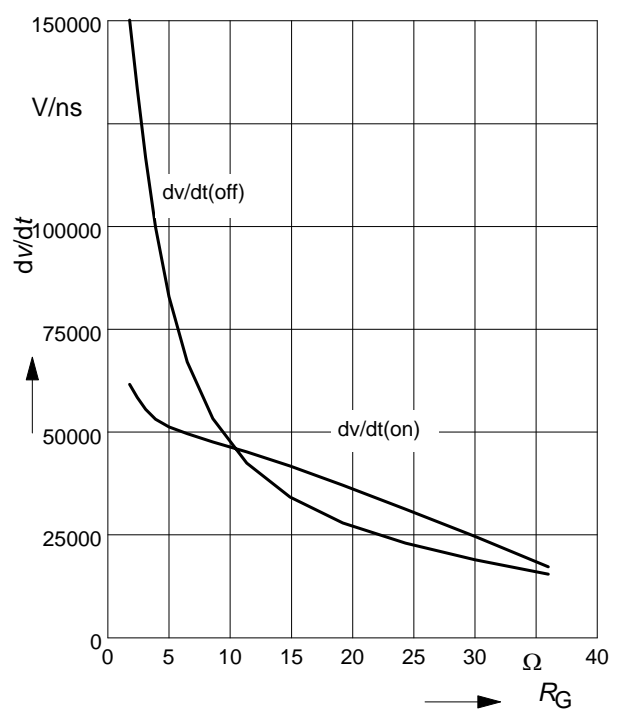
**14 Typ. drain current slope**

$di/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=8.1\text{A}$



**15 Typ. drain source voltage slope**

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$   
 par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=8.1\text{A}$

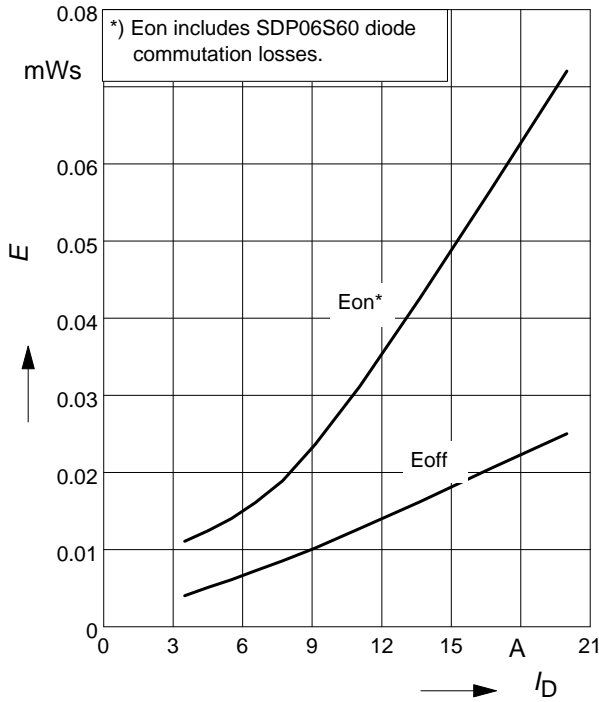




**16 Typ. switching losses**

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

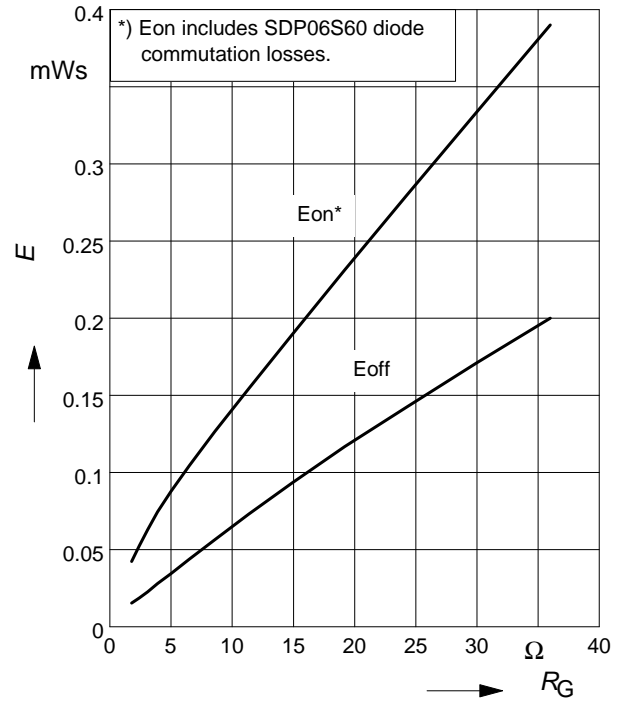
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 3.6\Omega$



**17 Typ. switching losses**

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

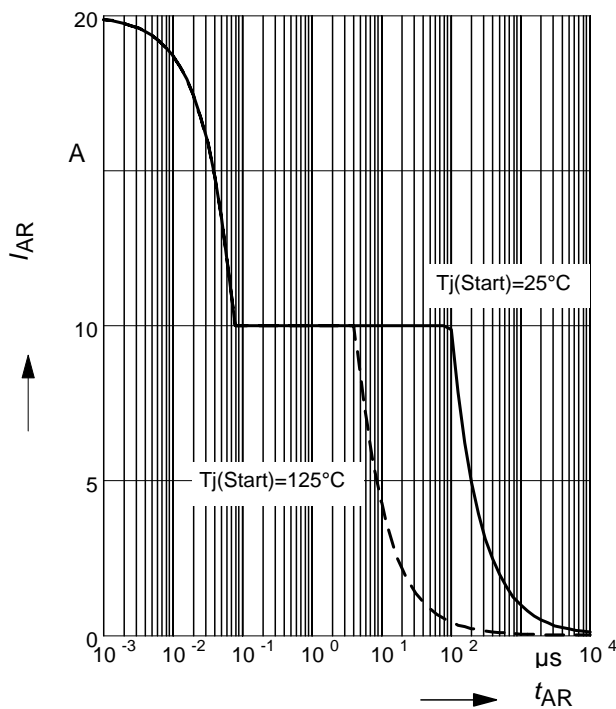
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 8.1\text{A}$



**18 Avalanche SOA**

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

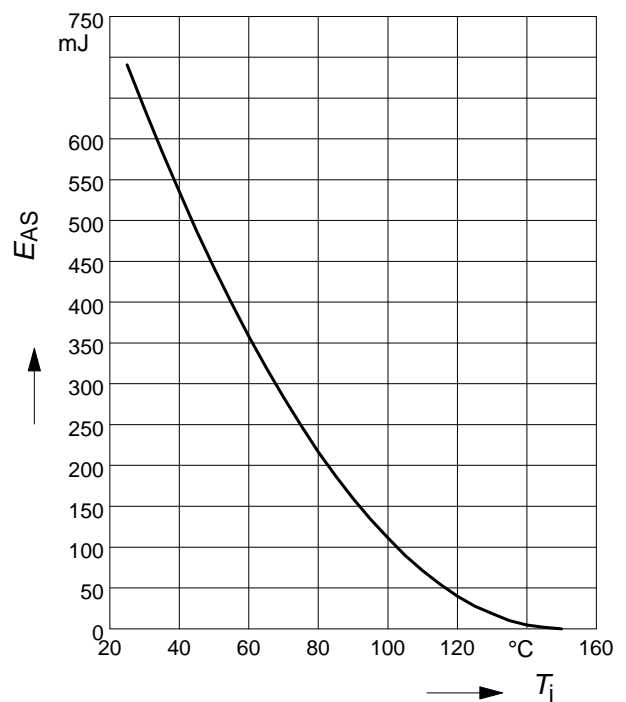
par.:  $T_j \leq 150^\circ\text{C}$



**19 Avalanche energy**

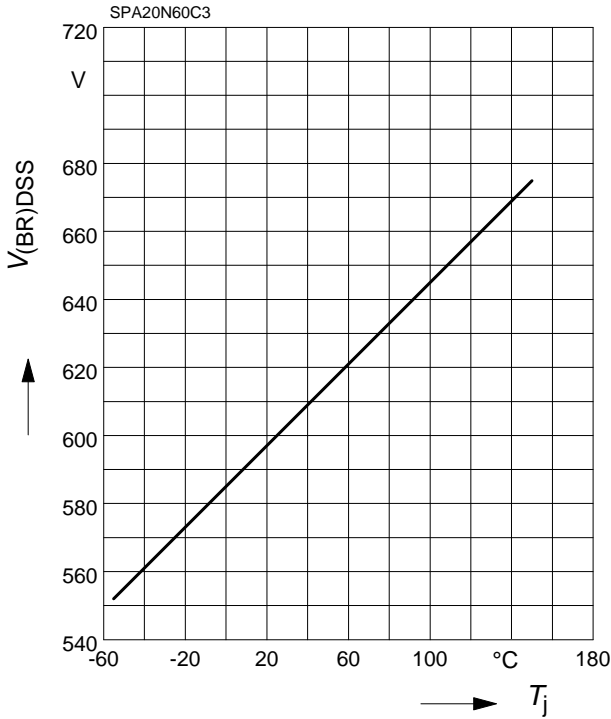
$E_{AS} = f(T_j)$

par.:  $I_D = 10\text{A}$ ,  $V_{DD} = 50\text{V}$



**20 Drain-source breakdown voltage**

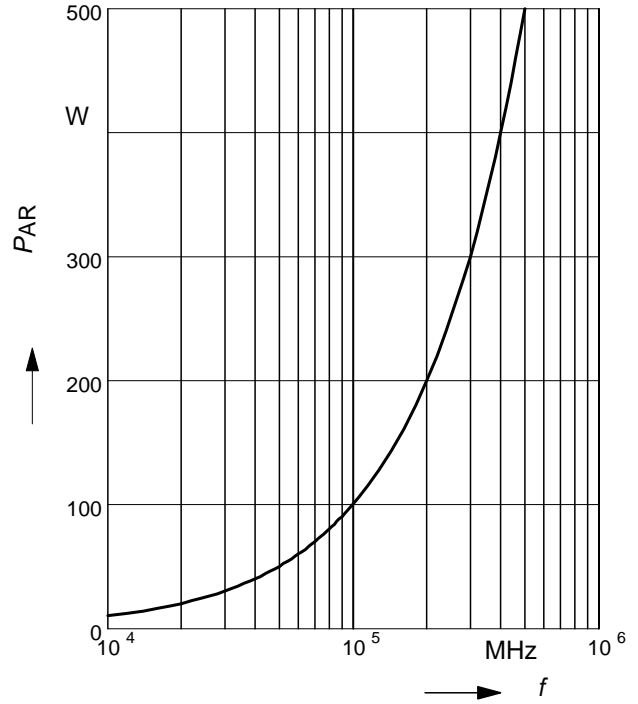
$$V_{(BR)DSS} = f(T_j)$$



**21 Avalanche power losses**

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

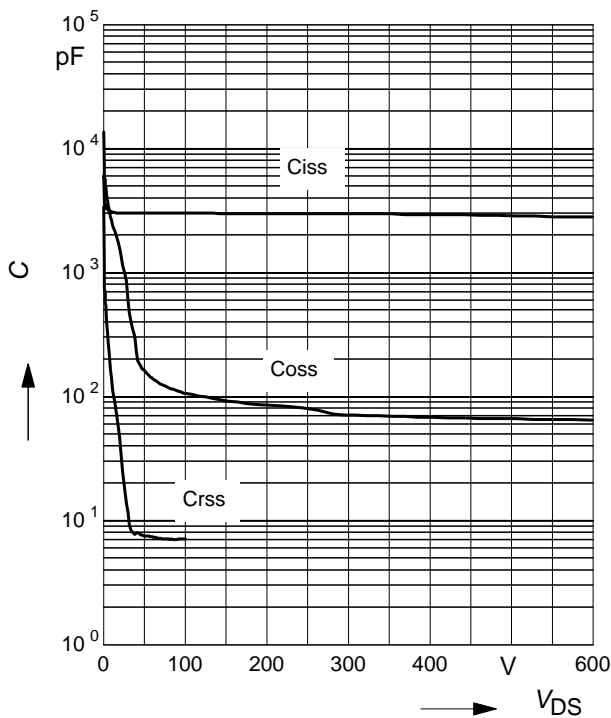
parameter:  $E_{AR}=1mJ$



**22 Typ. capacitances**

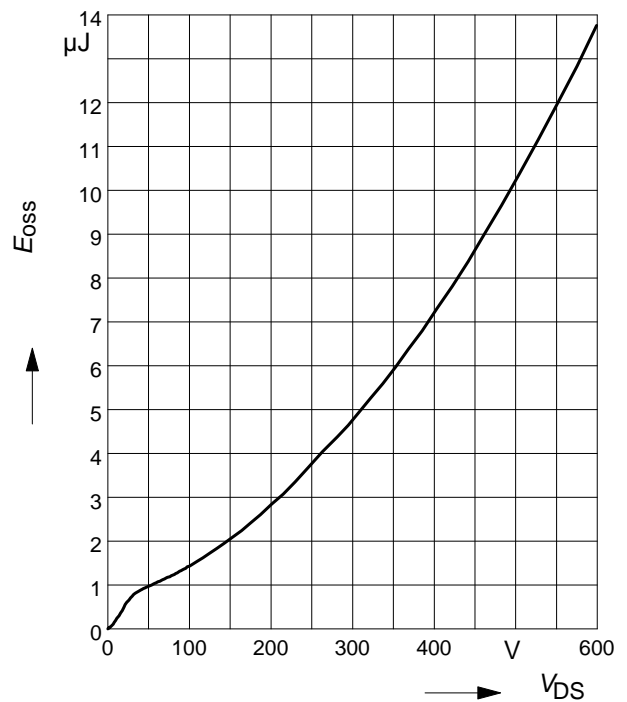
$$C = f(V_{DS})$$

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

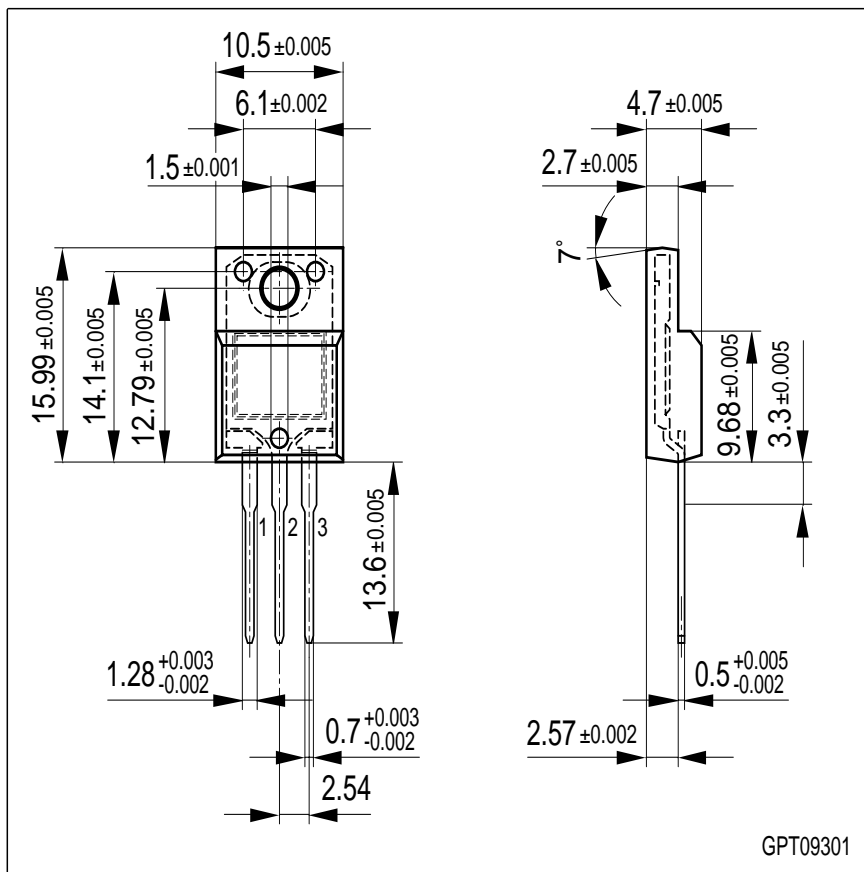
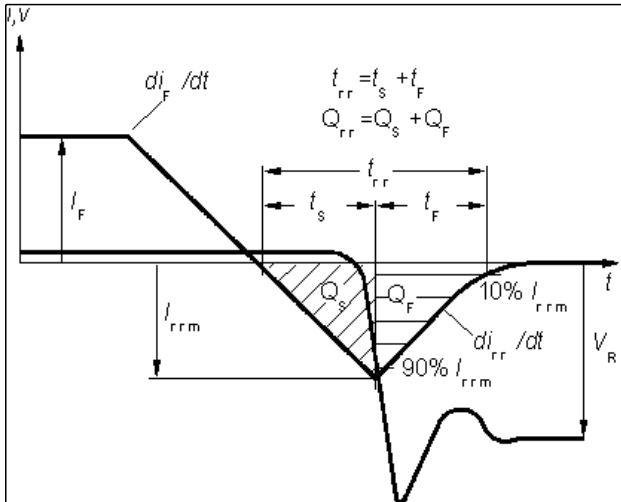


**23 Typ.  $C_{OSS}$  stored energy**

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



Definition of diodes switching characteristics



Please refer to mounting instructions (application note AN-TO220-3-31-01)

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