

Cool MOS™ Power Transistor

Feature

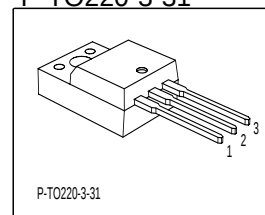
- New revolutionary high voltage technology
- Worldwide best $R_{DS(on)}$ in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- 150 °C operating temperature



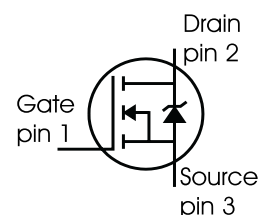
Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.19	Ω
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	I_D	8.1	A
$T_C = 25\text{ °C}$			
$T_C = 100\text{ °C}$		5.1	
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	62.1	
Avalanche energy, single pulse	E_{AS}	690	mJ
$I_D=10\text{A}$, $V_{DD}=50\text{V}$			
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ¹⁾	E_{AR}	1	
$I_D=20\text{A}$, $V_{DD}=50\text{V}$			
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	20	A
Reverse diode dv/dt	dv/dt	6	V/ns
$I_S=8.1\text{A}$, $V_{DS} < V_{DD}$, $di/dt=100\text{A}/\mu\text{s}$, $T_{jmax}=150\text{ °C}$			
Gate source voltage static	V_{GS}	± 20	V
Gate source voltage dynamic	V_{GS}	± 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.	
Characteristics					
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	-	

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

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

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

¹⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

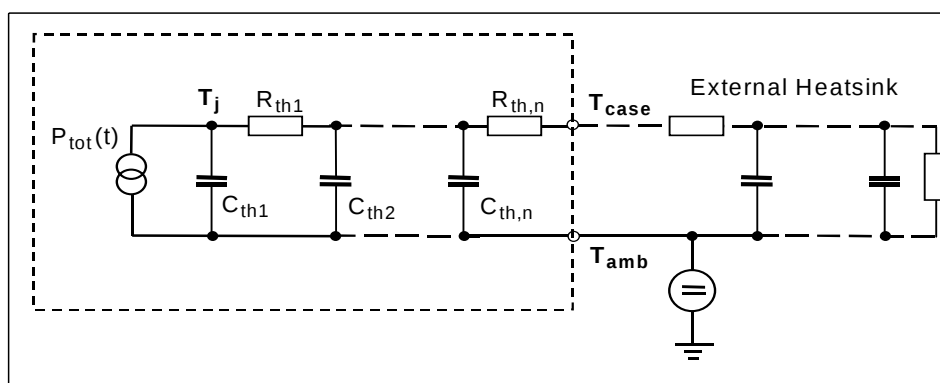
²⁾ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

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

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
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}	$V_R=480\text{V}, I_F=I_S$, $di_F/dt=100\text{A}/\mu\text{s}$	-	500	800	ns
Reverse recovery charge	Q_{rr}		-	11	-	μC
Peak reverse recovery current	I_{rrm}		-	70	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt		-	1400	-	$\text{A}/\mu\text{s}$

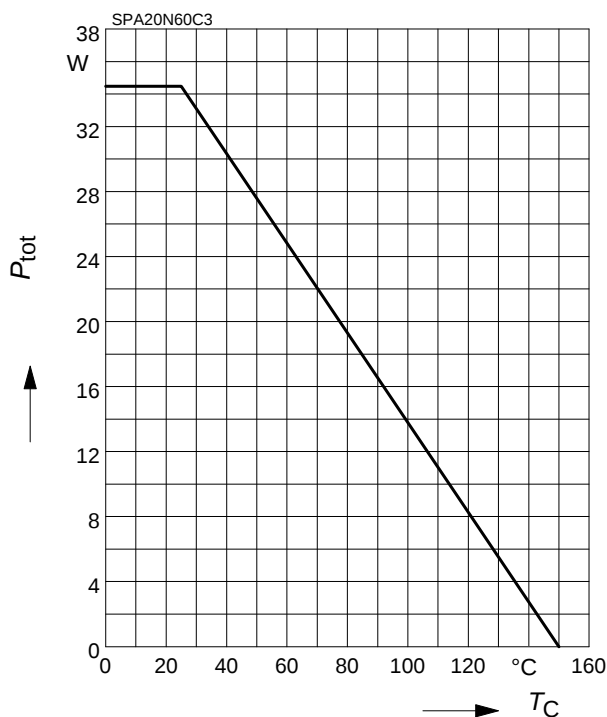
Transient Thermal Characteristics

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

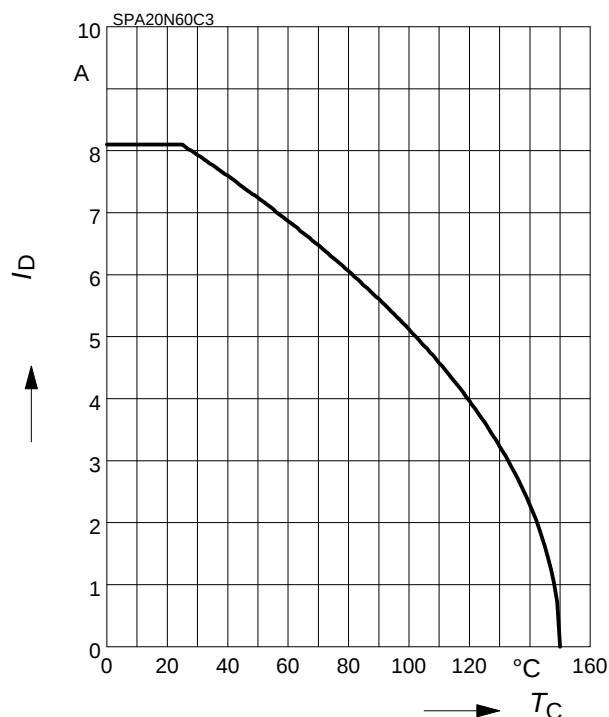
$$P_{\text{tot}} = f(T_C)$$



2 Drain current

$$I_D = f(T_C)$$

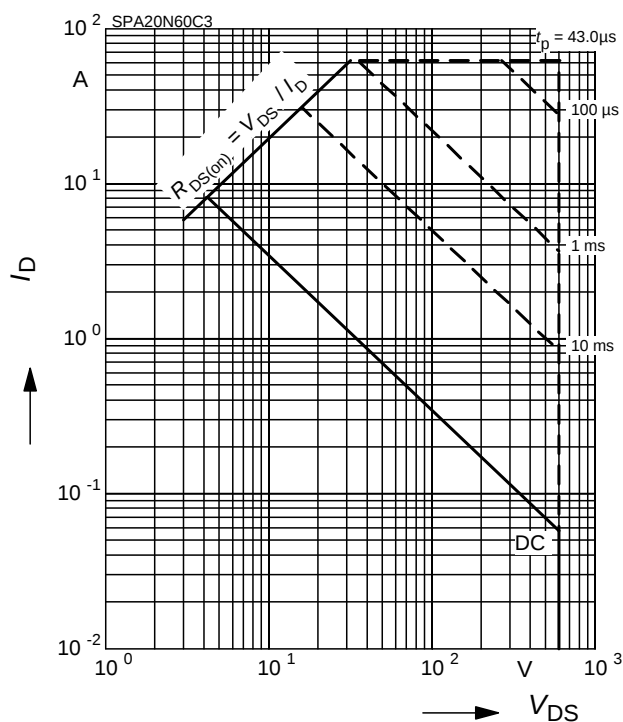
parameter: $V_{GS} \geq 10$ V



3 Safe operating area

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

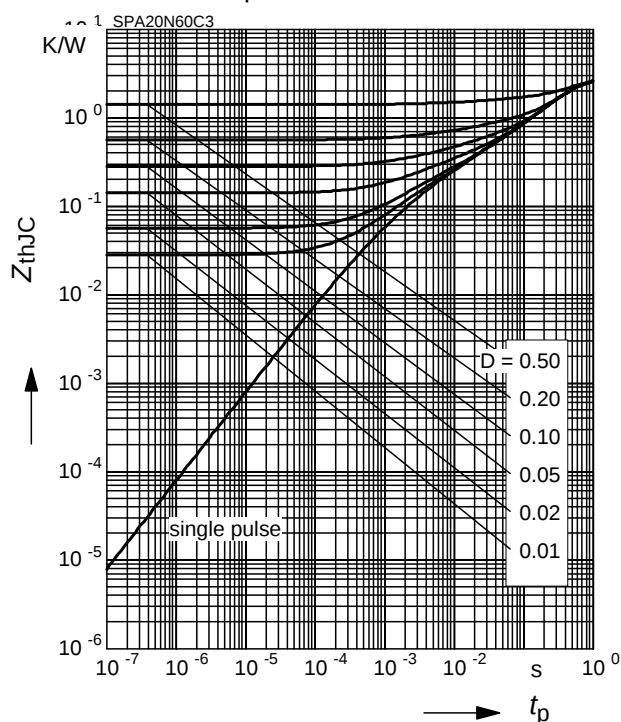
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Transient thermal impedance

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

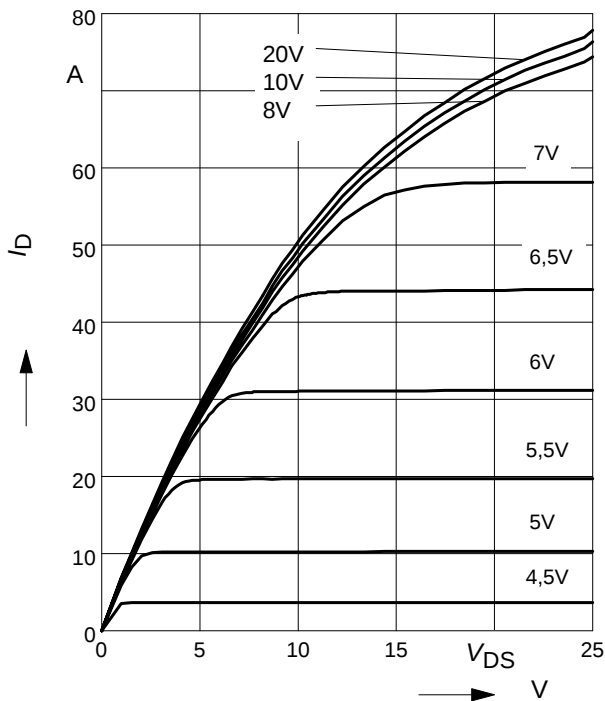
parameter : $D = t_p / T$



5 Typ. output characteristic

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

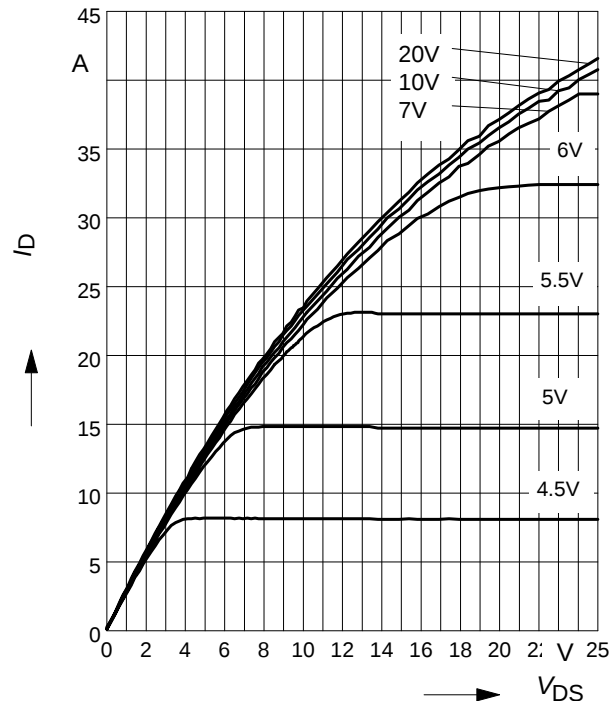
parameter: $t_p = 10\ \mu\text{s}$, V_{GS}



6 Typ. output characteristic

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

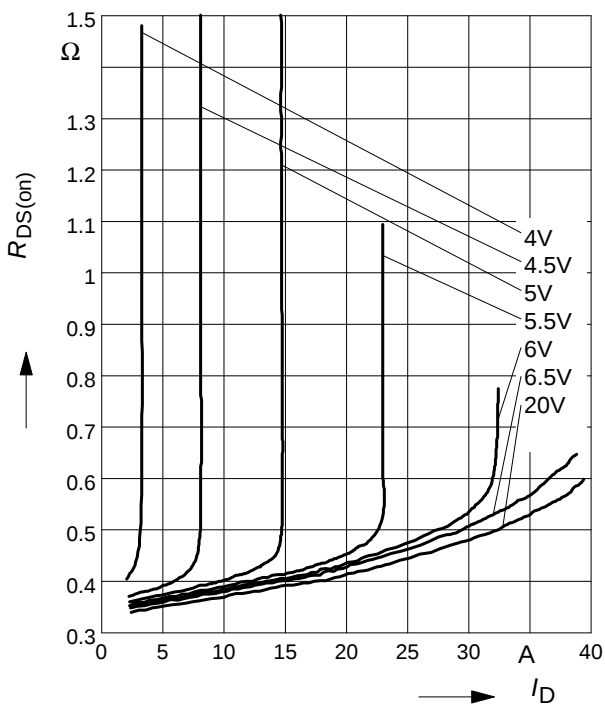
parameter: $t_p = 10\ \mu\text{s}$, V_{GS}



7 Typ. drain-source on resistance

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

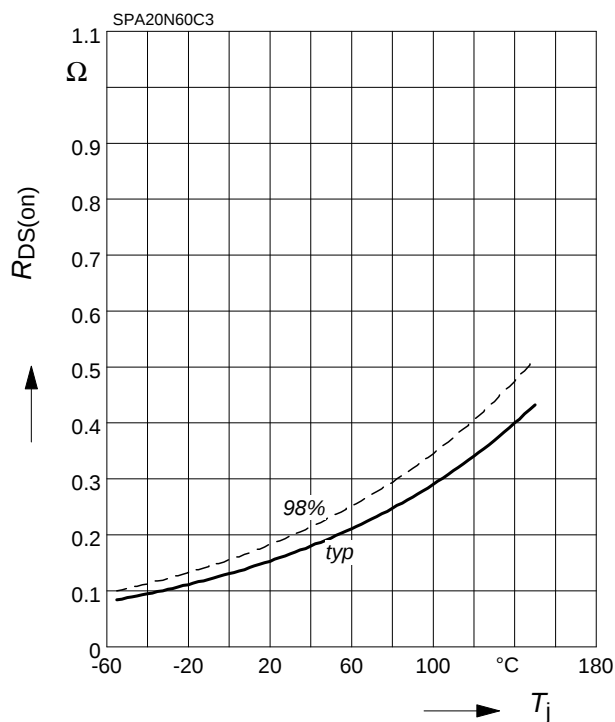
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



8 Drain-source on-state resistance

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

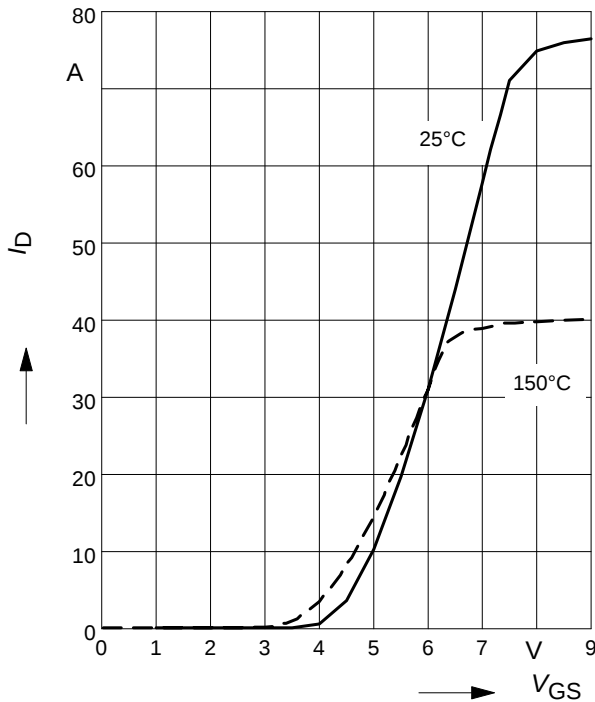
parameter: $I_D = 5.1\ \text{A}$, $V_{GS} = 10\ \text{V}$



9 Typ. transfer characteristics

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

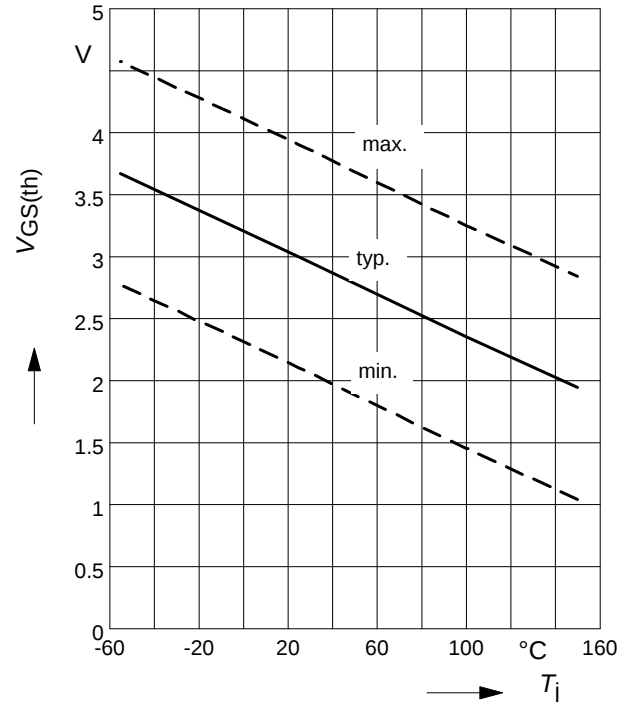
parameter: $t_p = 10 \mu s$



10 Gate threshold voltage

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

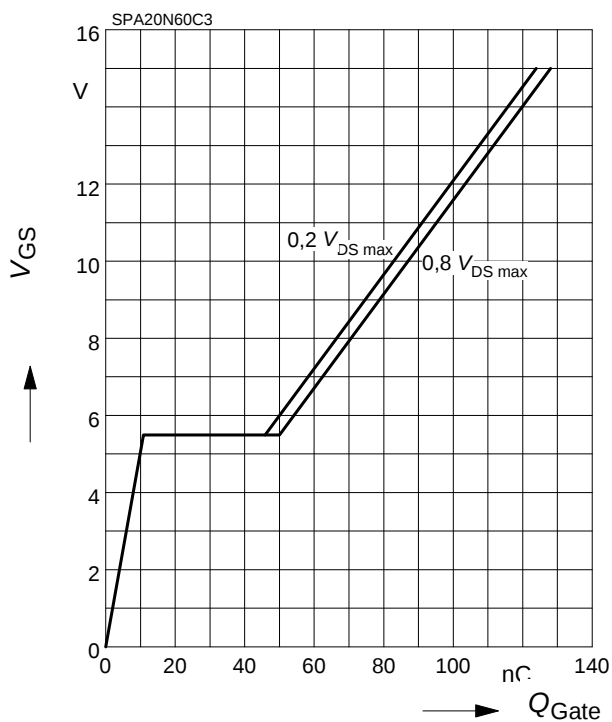
parameter: $V_{GS} = V_{DS}$, $I_D = 1 mA$



11 Typ. gate charge

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

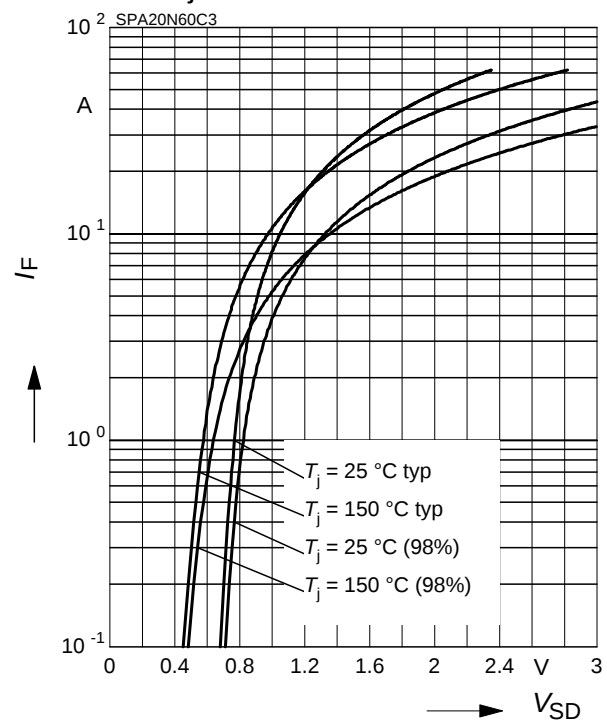
parameter: $I_D = 8.1 A$ pulsed



12 Forward characteristics of body diode

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

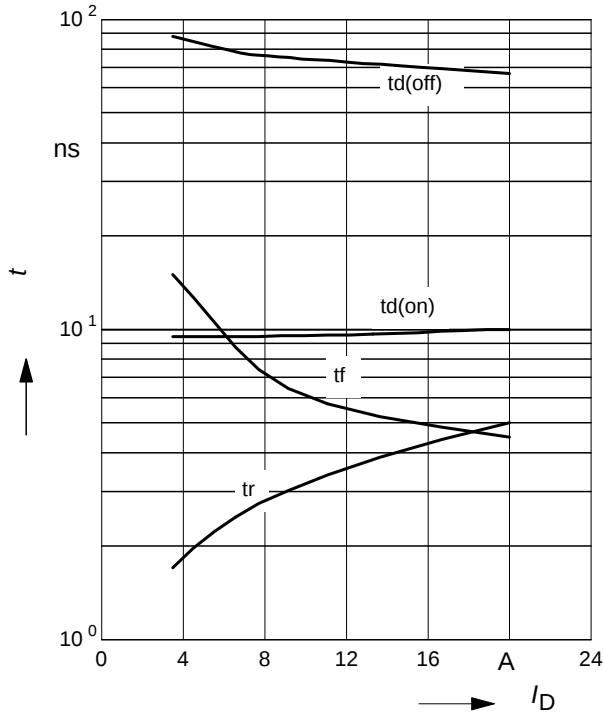
parameter: T_j , $t_p = 10 \mu s$



3.6 Typ. switching time

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

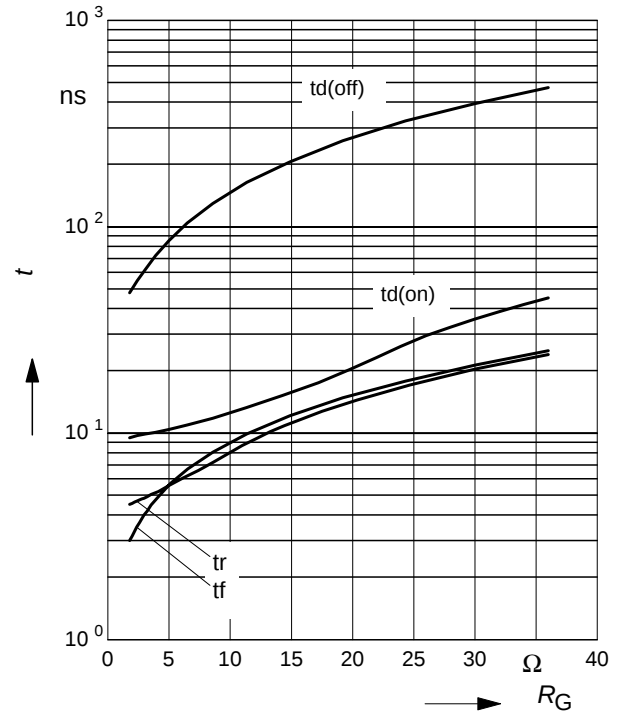
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $R_G = 3.6\Omega$



13 Typ. switching time

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

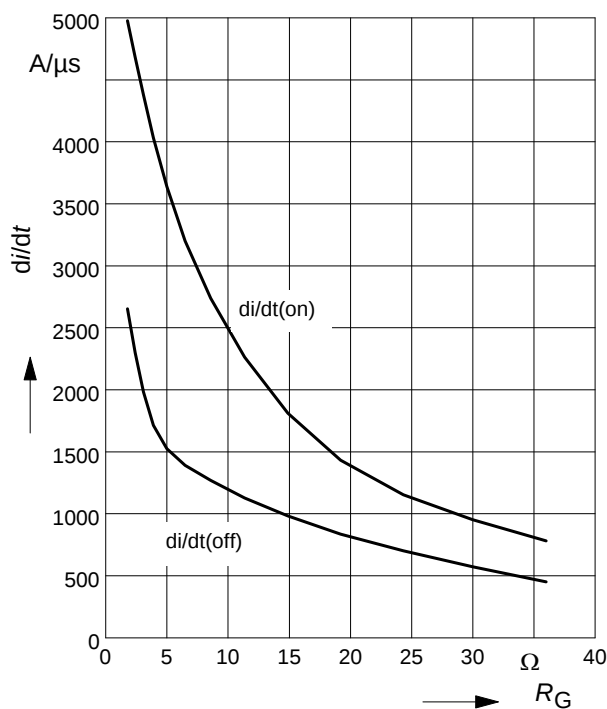
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 8.1\text{A}$



14 Typ. drain current slope

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

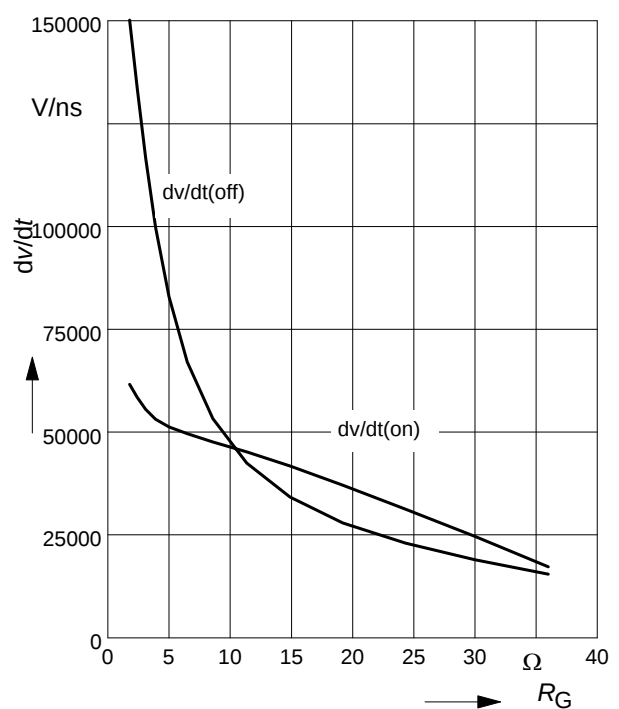
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 8.1\text{A}$



15 Typ. drain source voltage slope

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

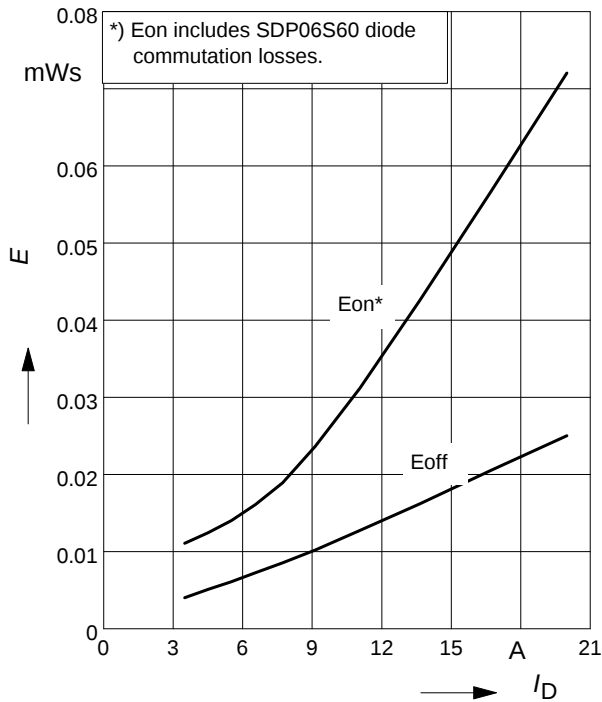
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 8.1\text{A}$



16 Typ. switching losses

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

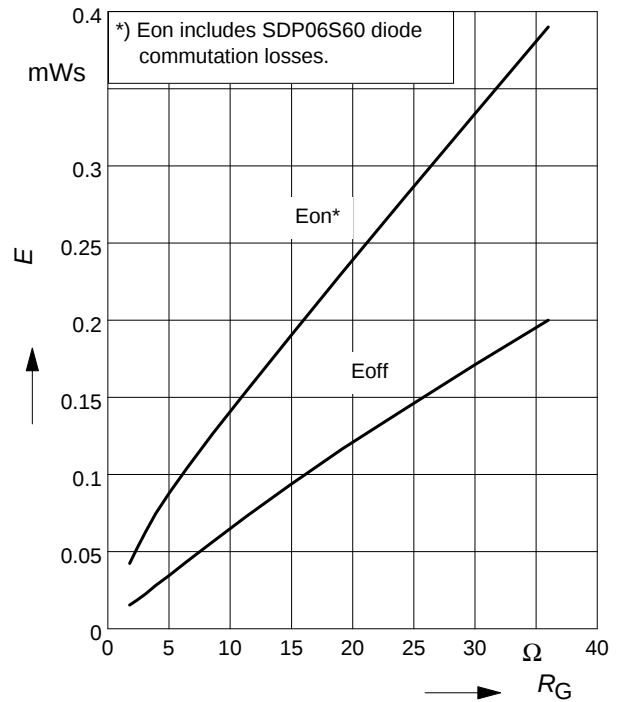
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $R_G = 3.6\Omega$



17 Typ. switching losses

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

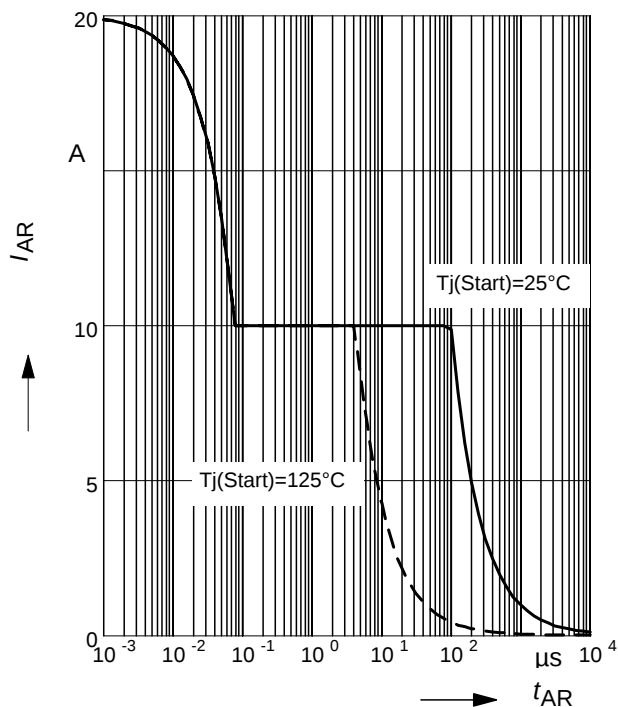
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 8.1\text{A}$



18 Avalanche SOA

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

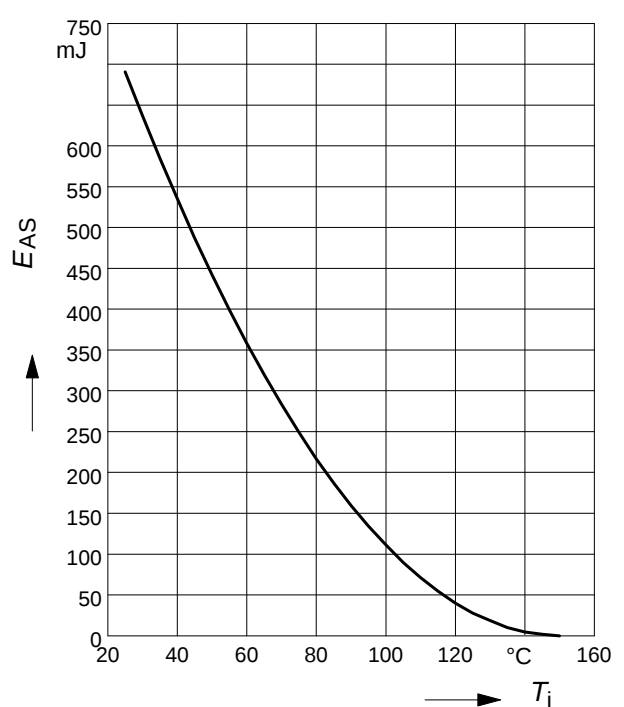
par.: $T_j \leq 150^\circ\text{C}$



19 Avalanche energy

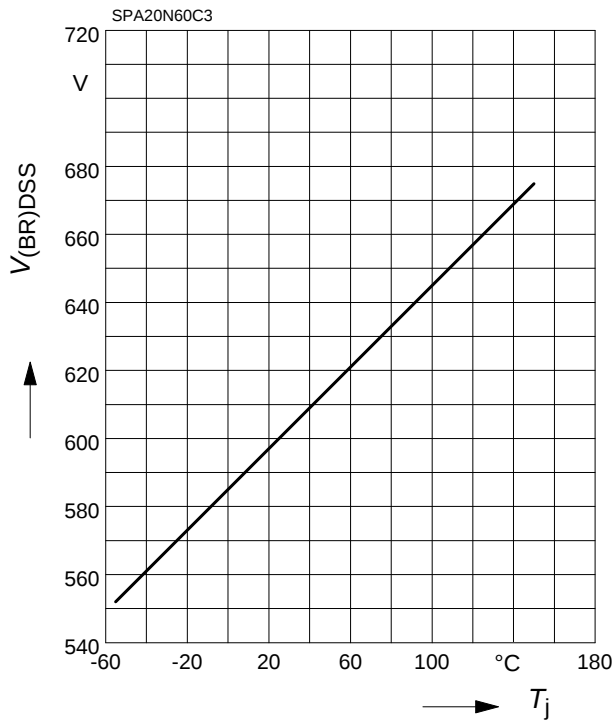
$E_{AS} = f(T_j)$

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



20 Drain-source breakdown voltage

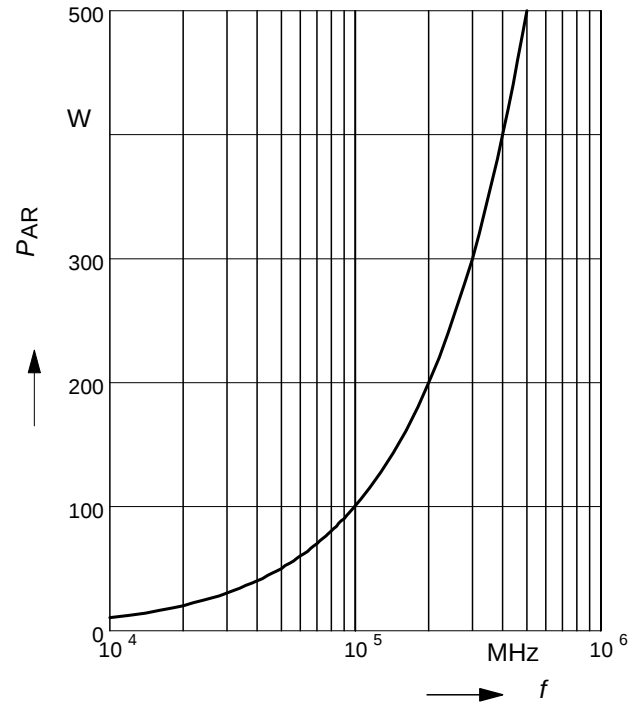
$$V_{(BR)DSS} = f(T_j)$$



21 Avalanche power losses

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

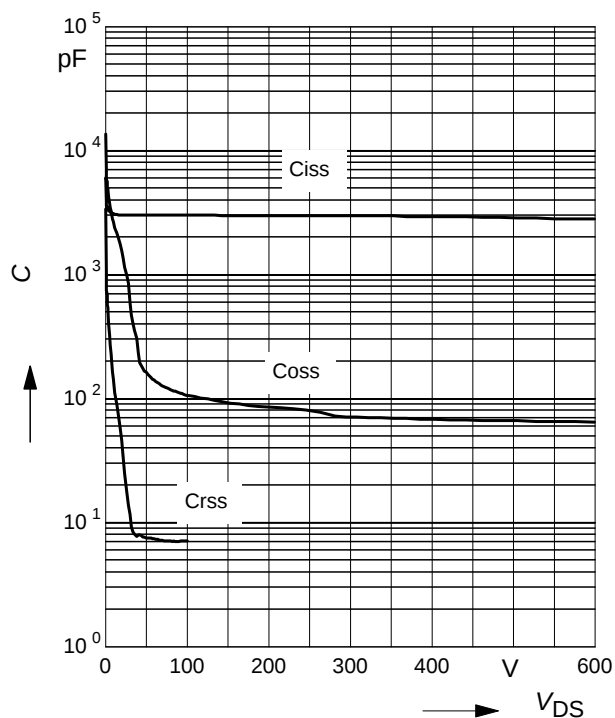
parameter: $E_{AR}=1\text{mJ}$



22 Typ. capacitances

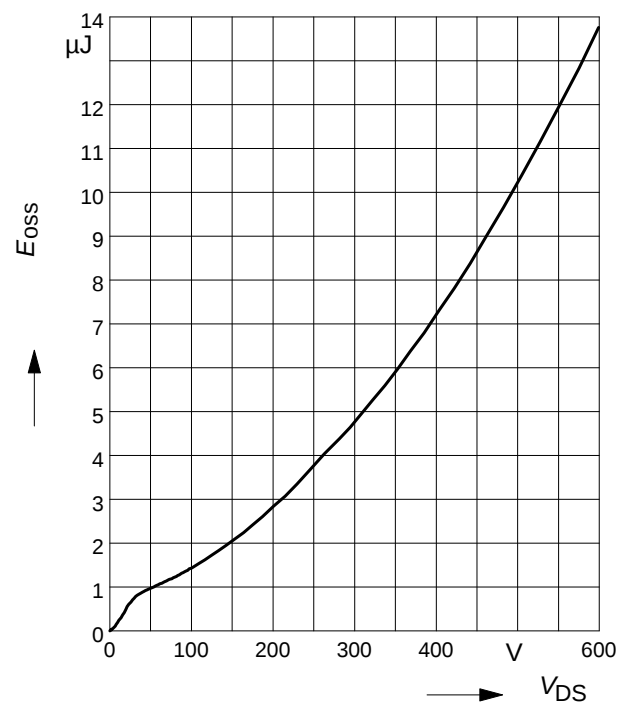
$$C = f(V_{DS})$$

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

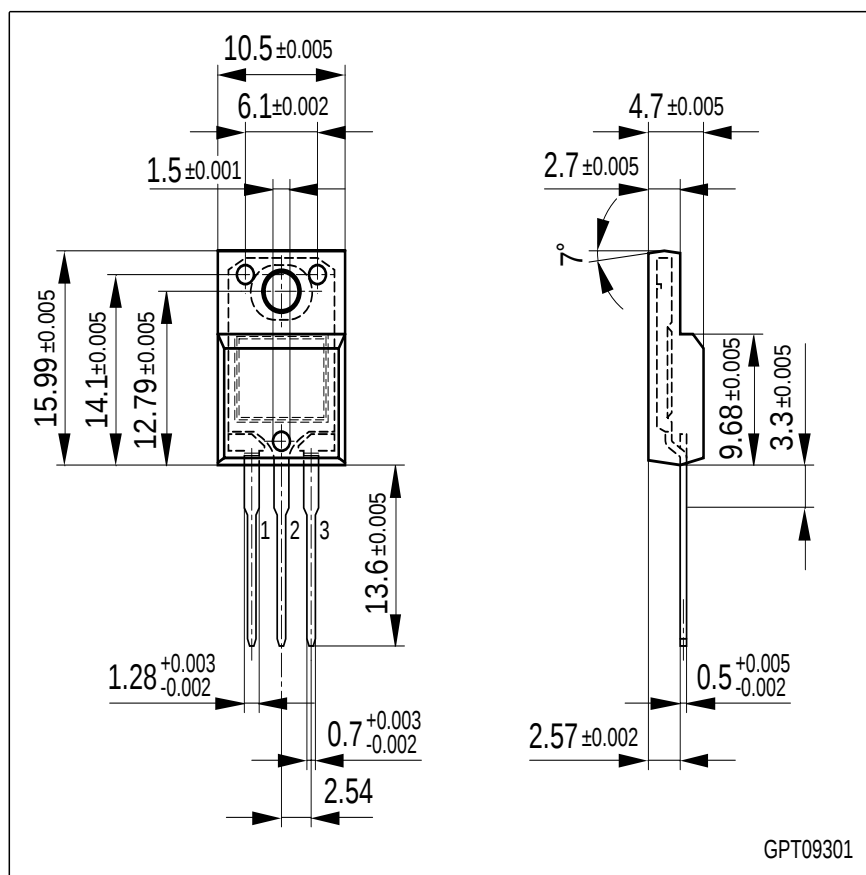
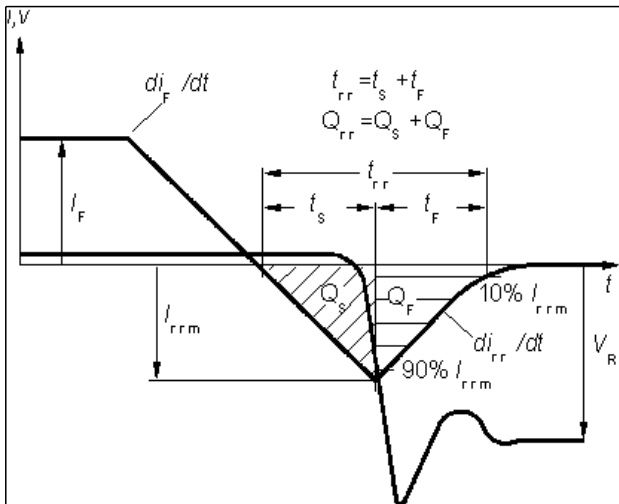


23 Typ. C_{oss} stored energy

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



Definition of diodes switching characteristics



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

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