

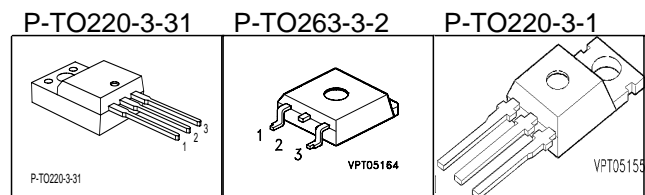
Cool MOS™ Power Transistor

Feature

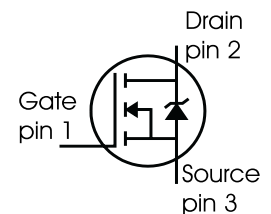
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- High peak current capability
- Improved transconductance
- 150 °C operating temperature

Product Summary

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



Type	Package	Ordering Code	Marking
SPP04N60C3	P-TO220-3-1	Q67040-S4366	04N60C3
SPB04N60C3	P-TO263-3-2	Q67040-S4407	04N60C3
SPA04N60C3	P-TO220-3-31	Q67040-S4413	04N60C3



Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_B	SPA	
Continuous drain current $T_C = 25\text{ °C}$ $T_C = 100\text{ °C}$	I_D	4.5 2.8	4.5 ¹⁾ 2.8 ¹⁾	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	13.5	13.5	A
Avalanche energy, single pulse $I_D=2.3\text{A}, V_{DD}=50\text{V}$	E_{AS}	130	130	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=4.5\text{A}, V_{DD}=50\text{V}$	E_{AR}	0.4	0.4	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	4.5	4.5	A
Reverse diode dv/dt $I_S = 4.5\text{ A}, V_{DS} < V_{DD}, di/dt=100\text{A}/\mu\text{s}, T_{jmax}=150\text{ °C}$	dv/dt	6	6	V/ns
Gate source voltage static	V_{GS}	± 20	± 20	V
Gate source voltage AC ($f > 1\text{Hz}$)	V_{GS}	± 30	± 30	
Power dissipation, $T_C = 25\text{ °C}$	P_{tot}	50	31	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}	-	-	2.5	K/W
Thermal resistance, junction - case, FullPAK	R_{thJC_FP}	-	-	4	
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
Thermal resistance, junction - ambient, FullPAK	R_{thJA_FP}	-	-	80	
SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ³⁾	R_{thJA}	-	-	62	
		-	35	-	
Linear derating factor		-	-	0.4	W/K
Linear derating factor, FullPAK		-	-	0.25	
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, $V_{GS} = V_{DS}$ $I_D = 200\ \mu A$	$V_{GS(th)}$	2.1	3	3.9	
Zero gate voltage drain current $V_{DS} = 600\ V, V_{GS} = 0\ V, T_j = 25\text{ °C}$ $V_{DS} = 600\ V, V_{GS} = 0\ V, T_j = 150\text{ °C}$	I_{DSS}	-	0.5	1	μA
		-	-	50	
Gate-source leakage current $V_{GS}=30V, V_{DS}=0V$	I_{GSS}	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=2.8A, T_j=25\text{ °C}$ $V_{GS}=10V, I_D=2.8A, T_j=150\text{ °C}$	$R_{DS(on)}$	-	0.85	0.95	Ω
		-	2.35	2.62	
Gate input resistance $f = 1\text{ MHz, open drain}$	R_G	-	0.95	-	

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8A$	-	4.4	-	S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$,	-	490	-	pF
Output capacitance	C_{oss}	$f = 1MHz$	-	160	-	
Reverse transfer capacitance	C_{rss}		-	15	-	
Effective output capacitance, ⁴⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 0V$ to 480V	-	20	-	
Effective output capacitance, ⁵⁾ time related	$C_{o(tr)}$		-	35	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$, $V_{GS} = 0/10V$,	-	6	-	ns
Rise time	t_r	$I_D = 4.5A$,	-	2.5	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 18\Omega$	-	58.5	80	
Fall time	t_f		-	9.5	14	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 480V$, $I_D = 4.5A$	-	2.2	-	nC
Gate to drain charge	Q_{gd}		-	8.8	-	
Gate charge total	Q_g	$V_{DD} = 480V$, $I_D = 4.5A$, $V_{GS} = 0$ to 10V	-	19	25	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 480V$, $I_D = 4.5A$	-	5	-	V

¹Limited only by maximum temperature

²Repetitive avalanche causes additional power losses that can be calculated as $P_{AV} = E_{AR} \cdot f$.

³Device on 40mm*40mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air.

⁴ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

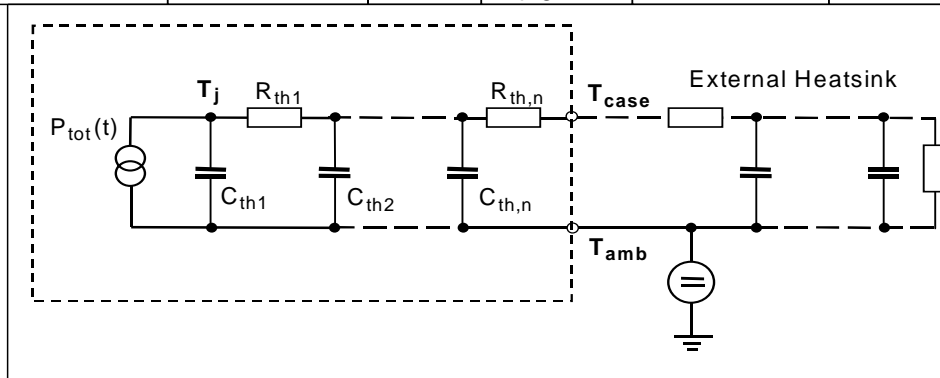
⁵ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
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	-	μC
Peak reverse recovery current	I_{rrm}		-	18	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^\circ\text{C}$	-	900	-	$\text{A}/\mu\text{s}$

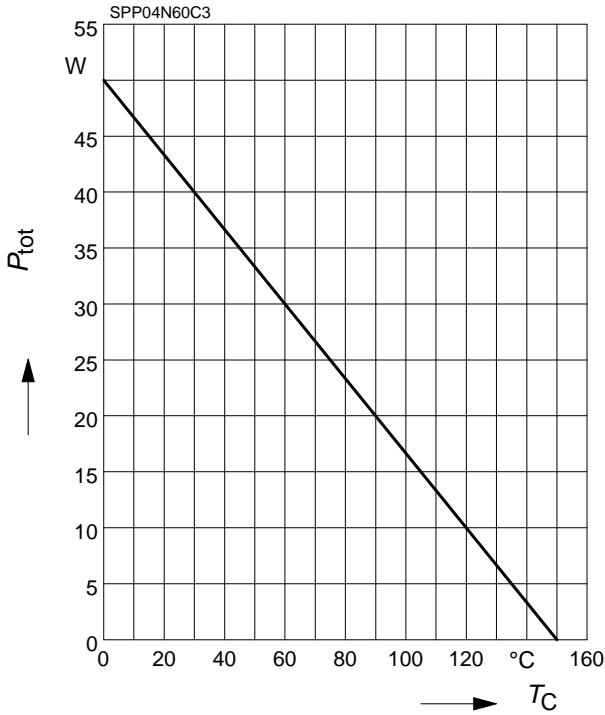
Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
R_{th1}	0.039	0.039	K/W	C_{th1}	0.00008293	0.0000734	Ws/K
R_{th2}	0.083	0.075		C_{th2}	0.000282	0.000282	
R_{th3}	0.133	0.102		C_{th3}	0.0004859	0.000401	
R_{th4}	0.275	0.27		C_{th4}	0.0011	0.000736	
R_{th5}	0.278	0.594		C_{th5}	0.00535	0.00501	
R_{th6}	0.093	2.536		C_{th6}	0.054	0.412	



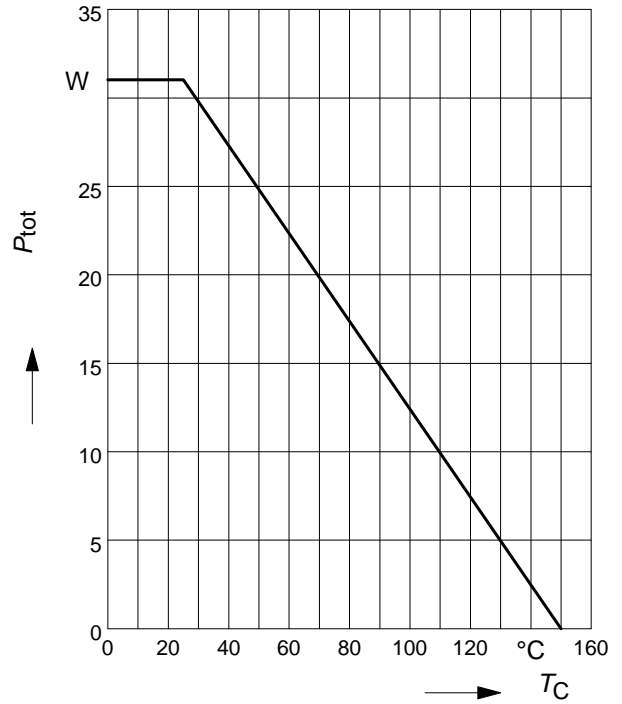
1 Power dissipation

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



2 Power dissipation FullPAK

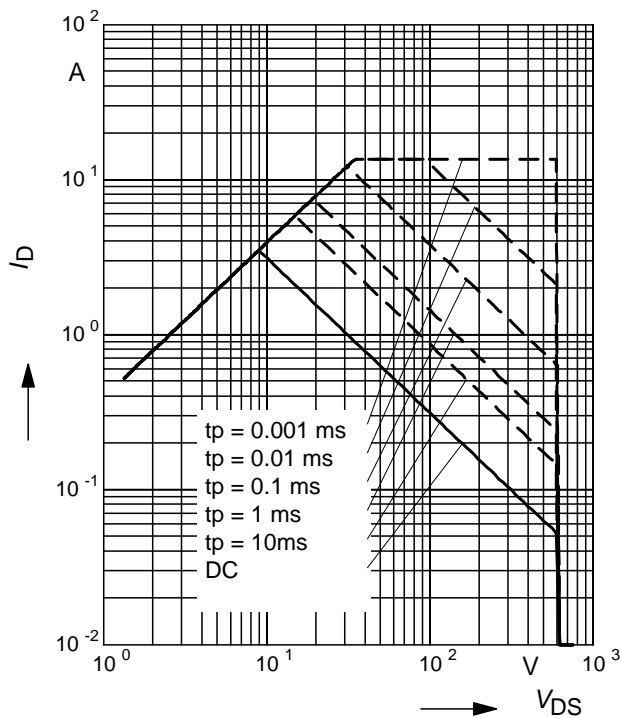
$$P_{tot} = f(T_C)$$



3 Safe operating area FullPAK

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

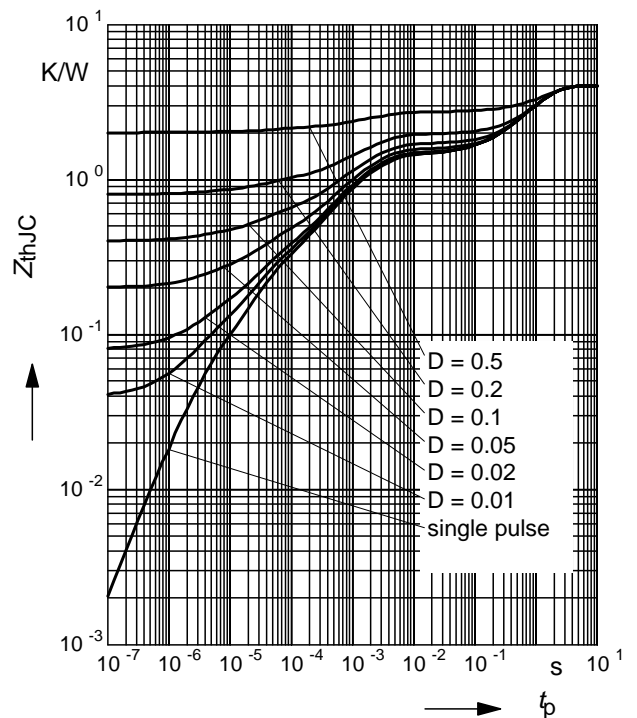
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



4 Transient thermal impedance FullPAK

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

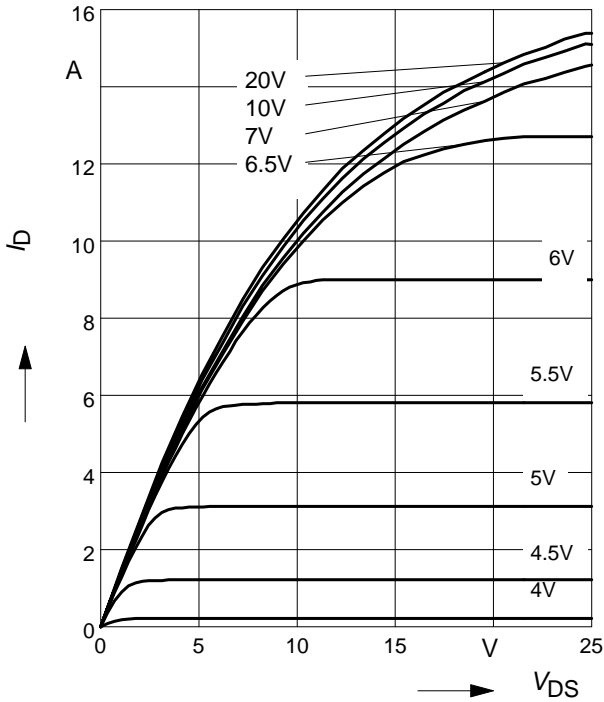
parameter: $D = t_p/t$



5 Typ. output characteristic

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

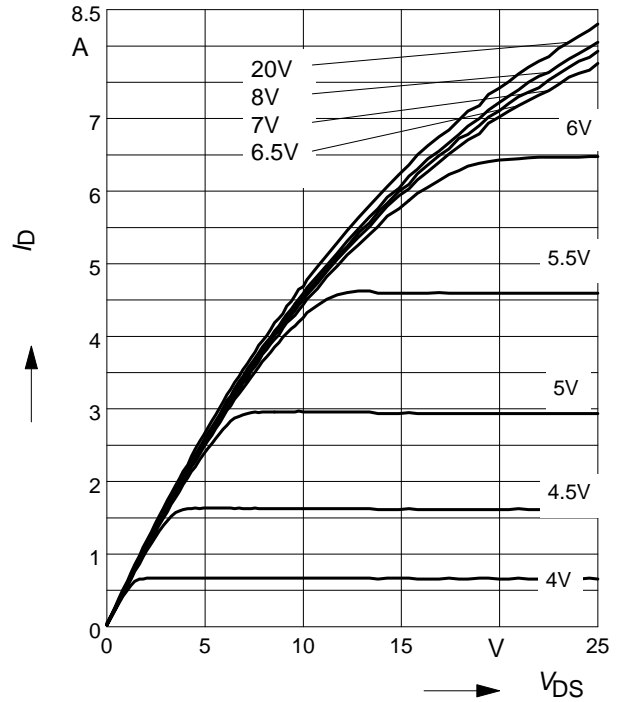
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



6 Typ. output characteristic

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

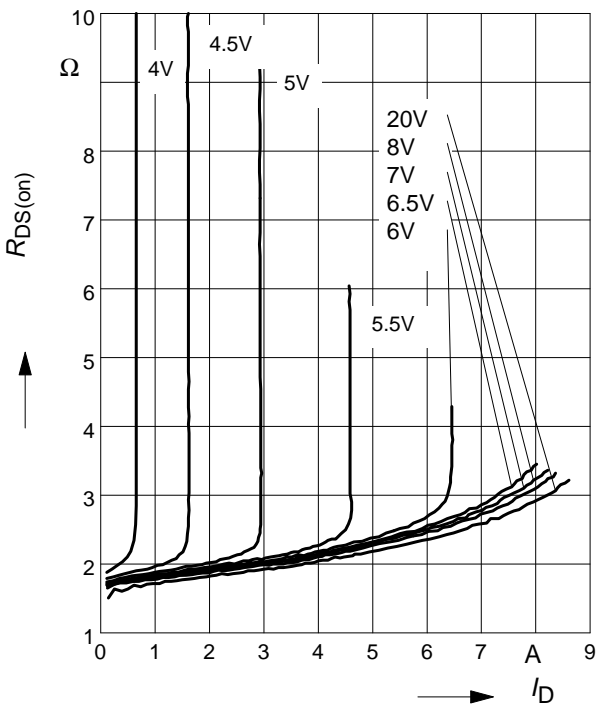
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



7 Typ. drain-source on resistance

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

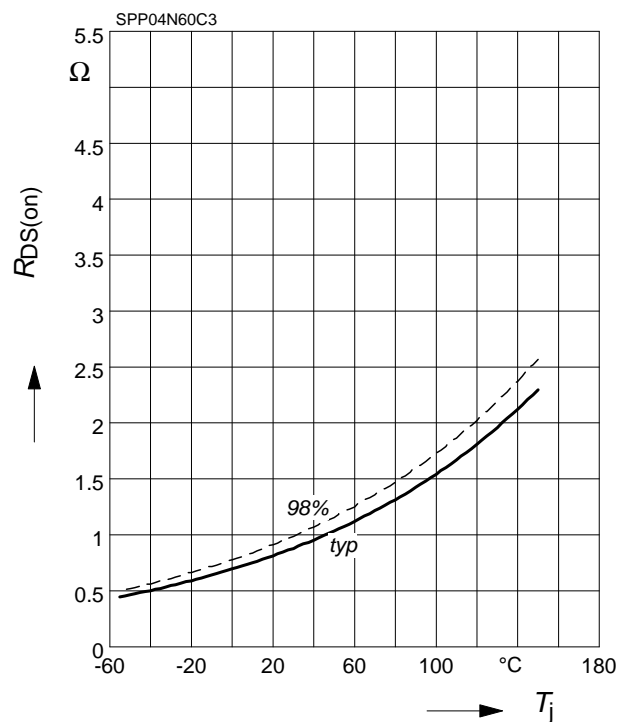
parameter: $T_j = 150^\circ\text{C}, V_{GS}$



8 Drain-source on-state resistance

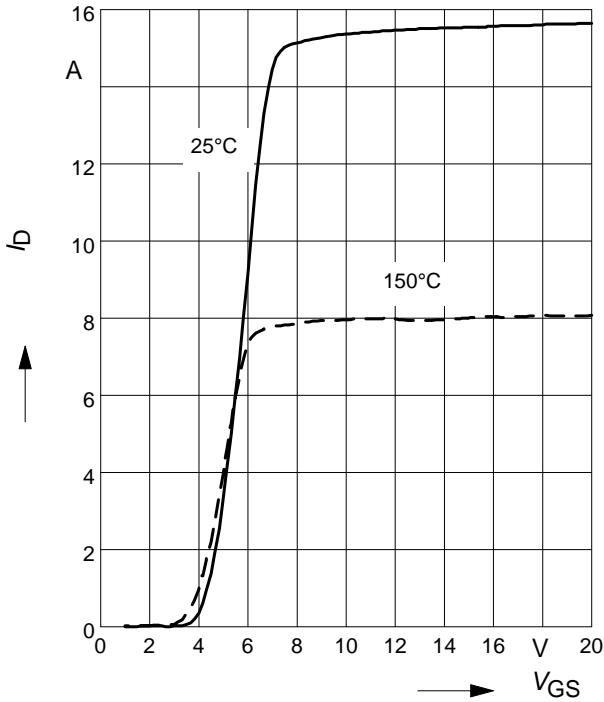
$R_{DS(on)} = f(T_j)$

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



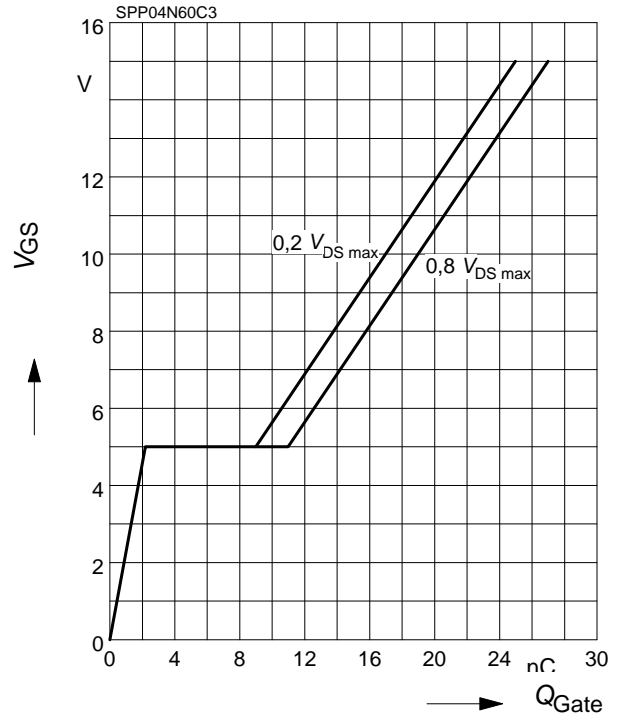
9 Typ. transfer characteristics

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



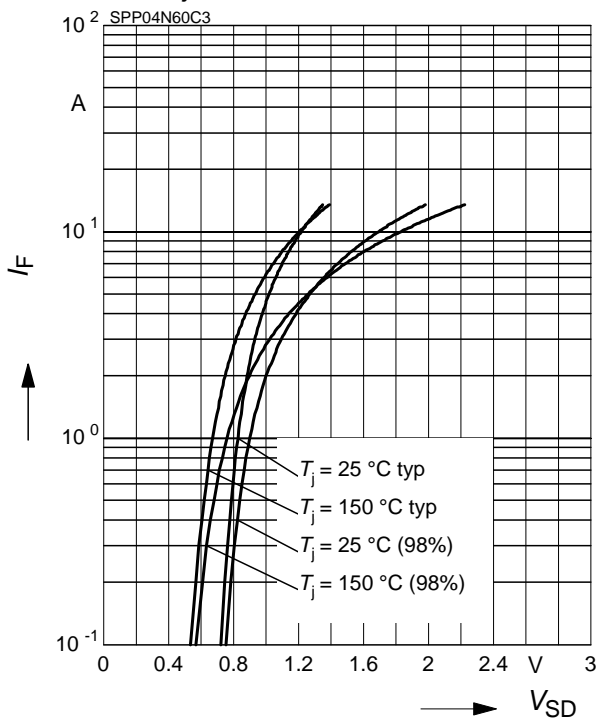
10 Typ. gate charge

$V_{GS} = f(Q_{Gate})$
parameter: $I_D = 4.5 A$ pulsed



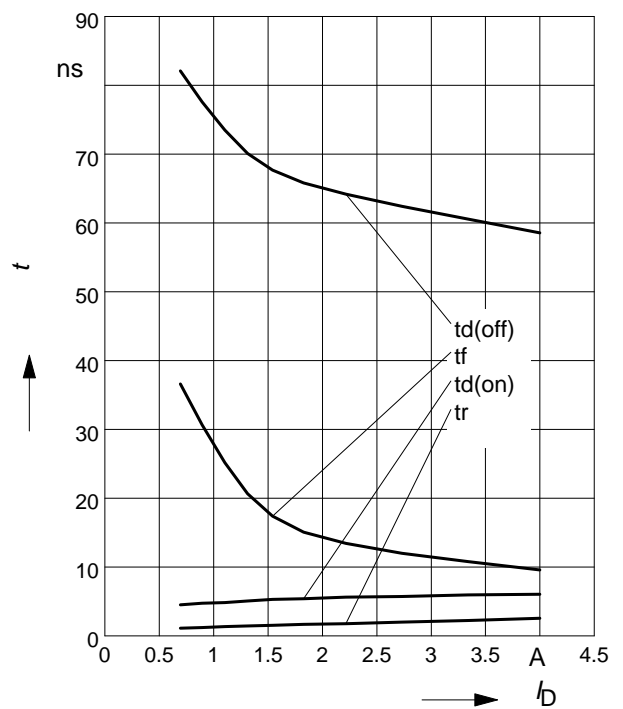
11 Forward characteristics of body diode

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



12 Typ. switching time

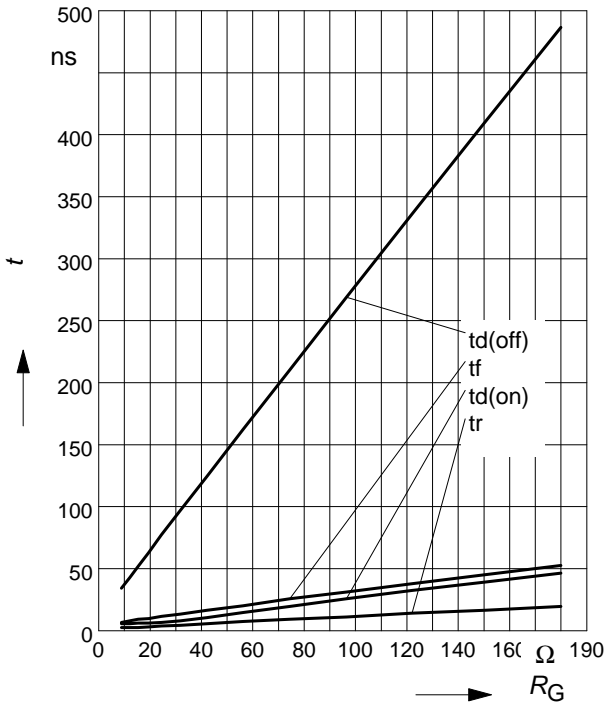
$t = f(I_D)$, inductive load, $T_j = 125^\circ C$
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $R_G = 18\Omega$



13 Typ. switching time

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

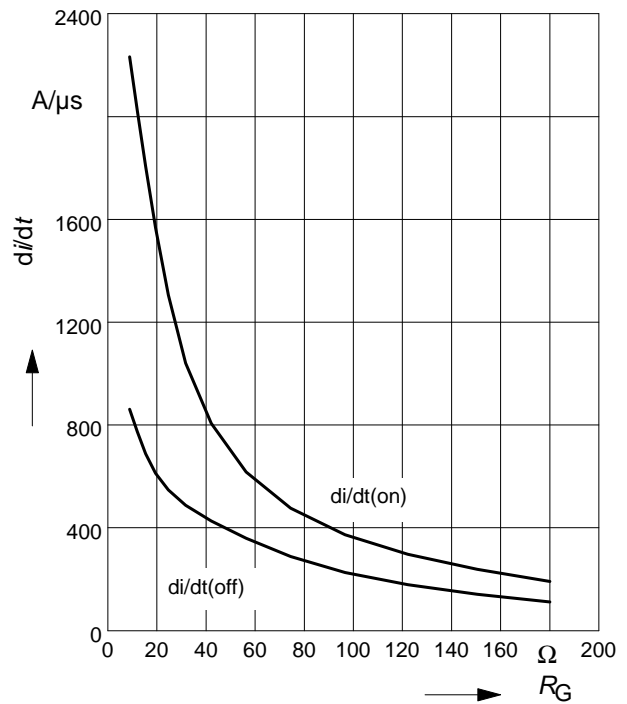
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



14 Typ. drain current slope

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

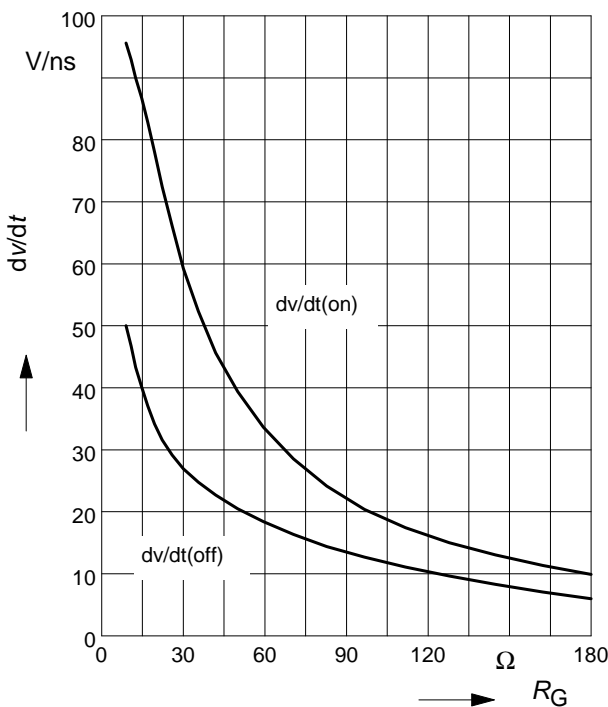
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



15 Typ. drain source voltage slope

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

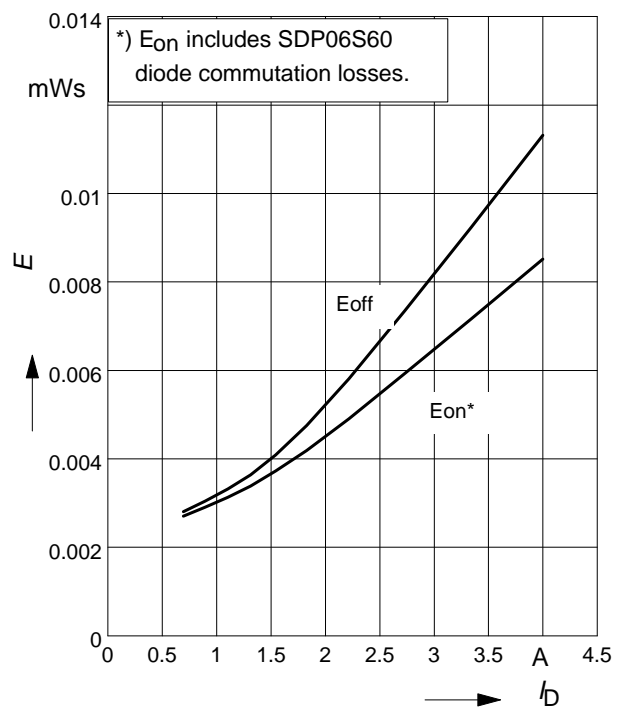
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



16 Typ. switching losses

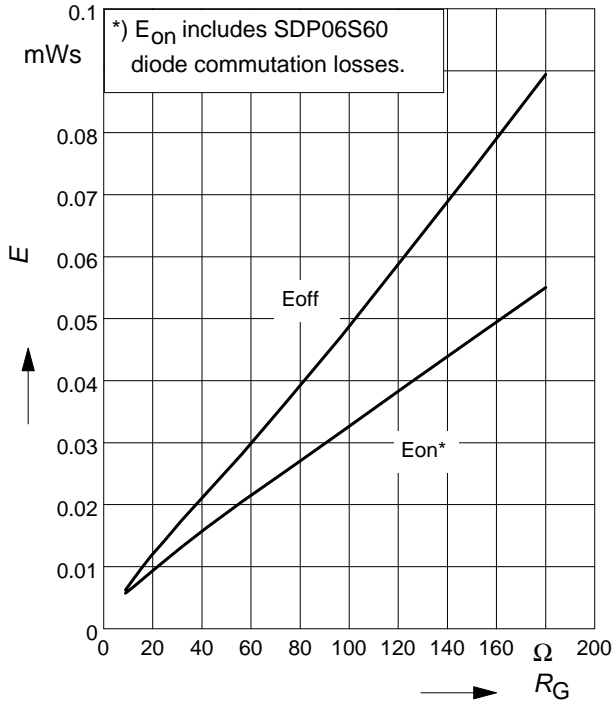
$E = f(I_D)$, inductive load, $T_j = 125^\circ\text{C}$

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



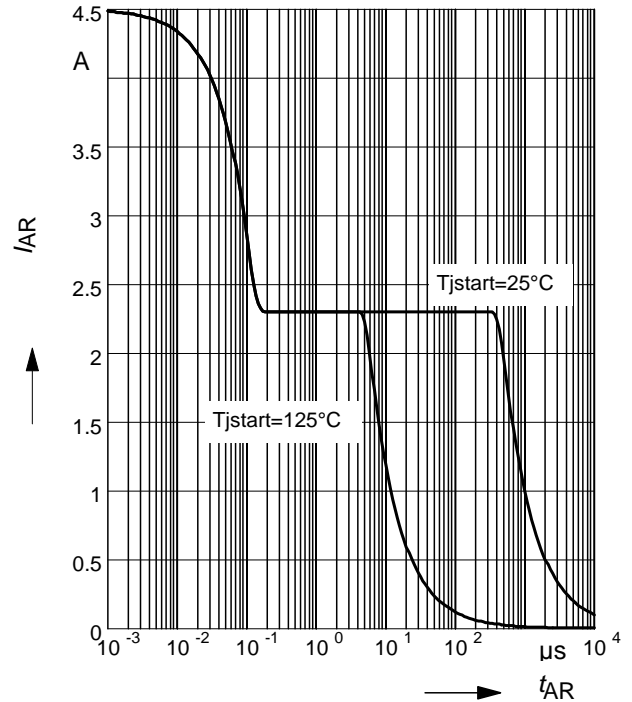
17 Typ. switching losses

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



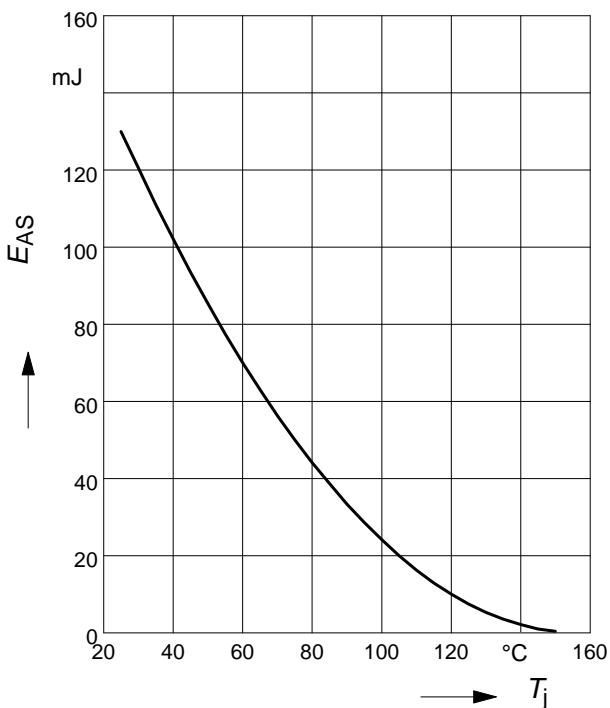
18 Avalanche SOA

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



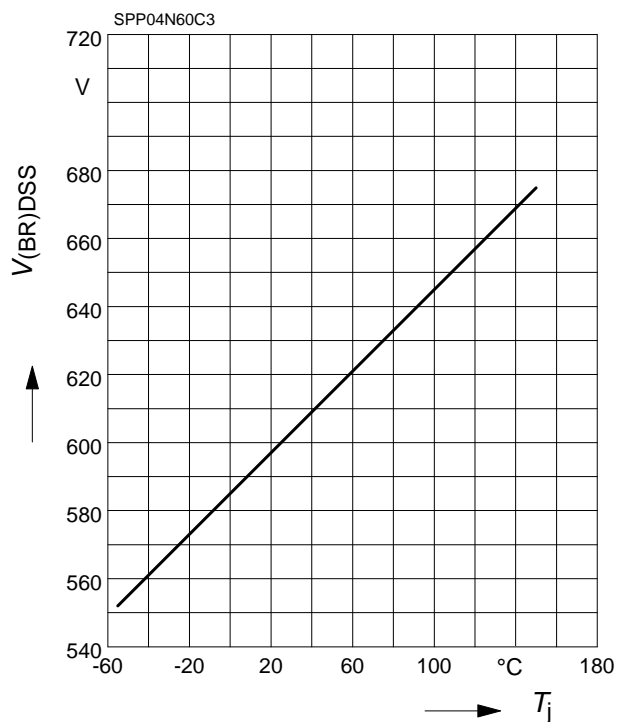
19 Avalanche energy

$E_{AS} = f(T_j)$
par.: $I_D = 2.3\text{A}$, $V_{DD} = 50\text{V}$



20 Drain-source breakdown voltage

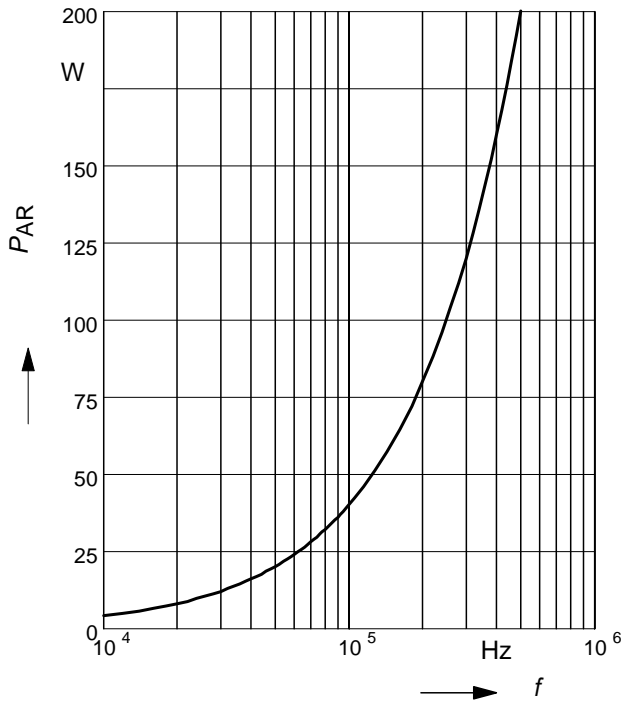
$V_{(BR)DSS} = f(T_j)$



21 Avalanche power losses

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

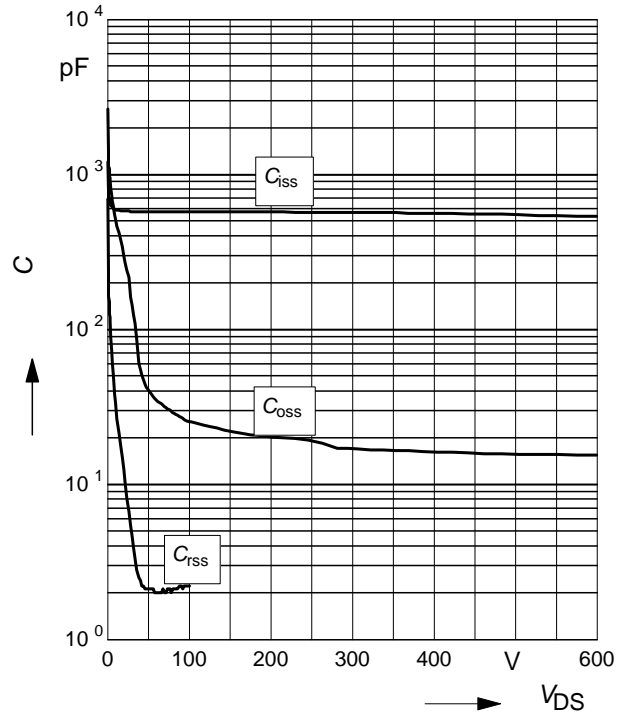
parameter: $E_{AR}=0.4\text{mJ}$



22 Typ. capacitances

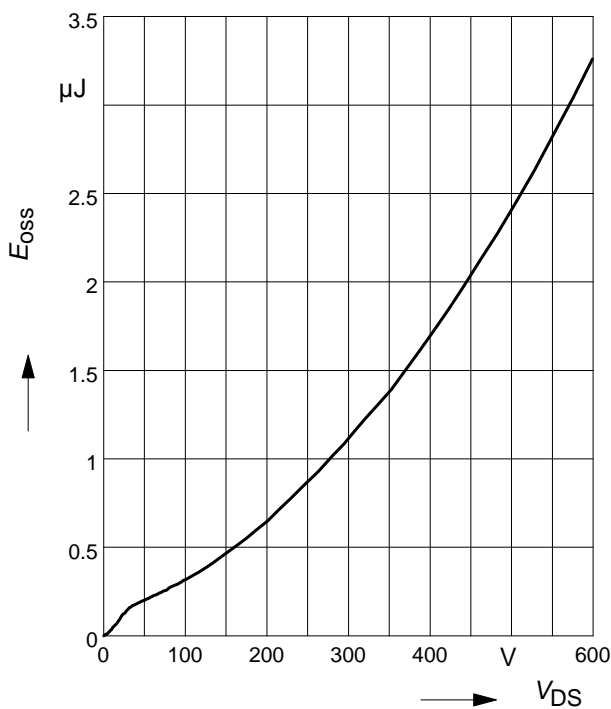
$$C = f(V_{DS})$$

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

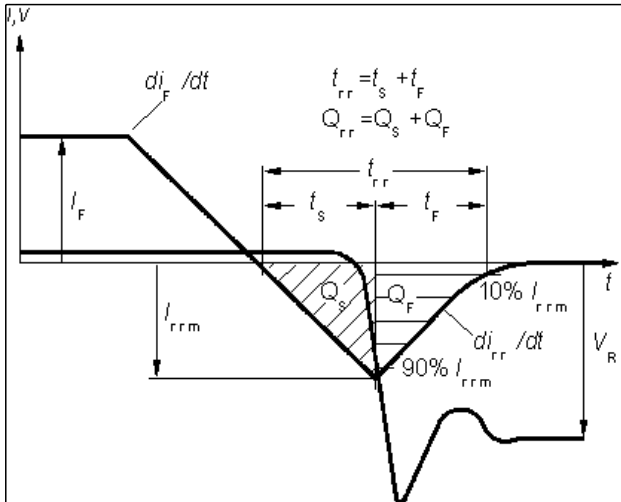


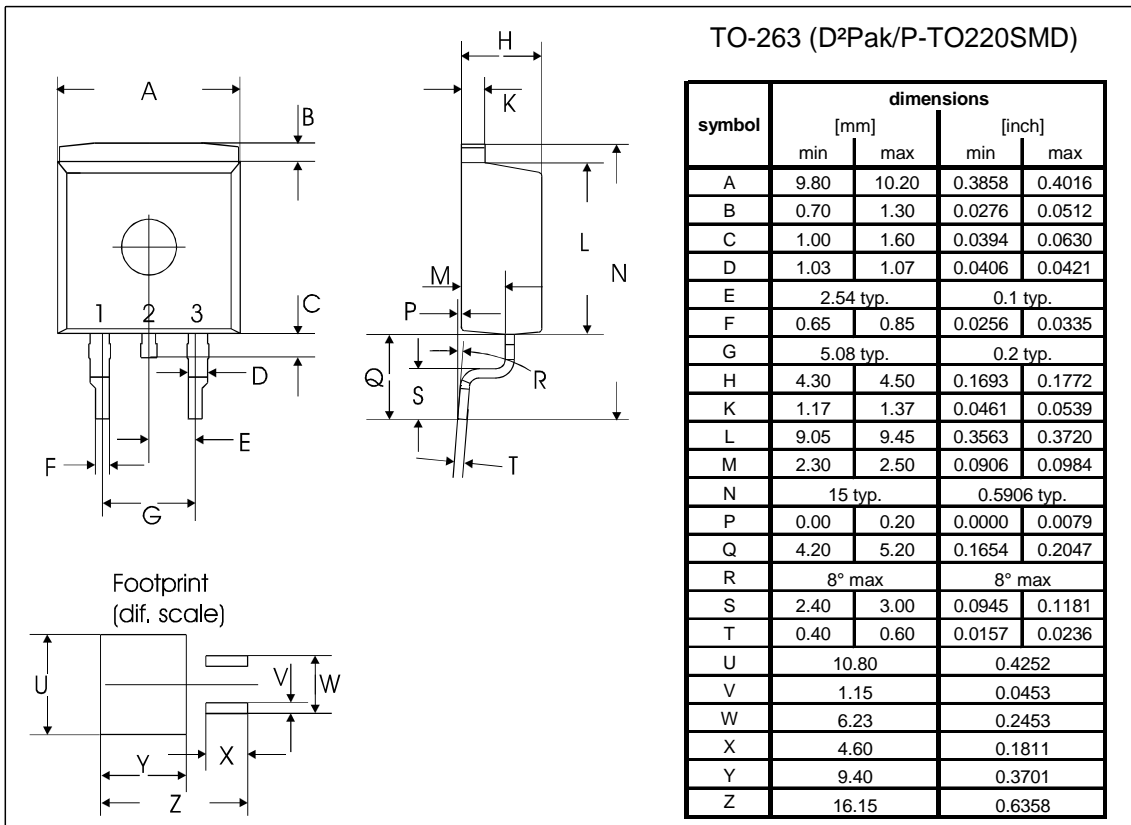
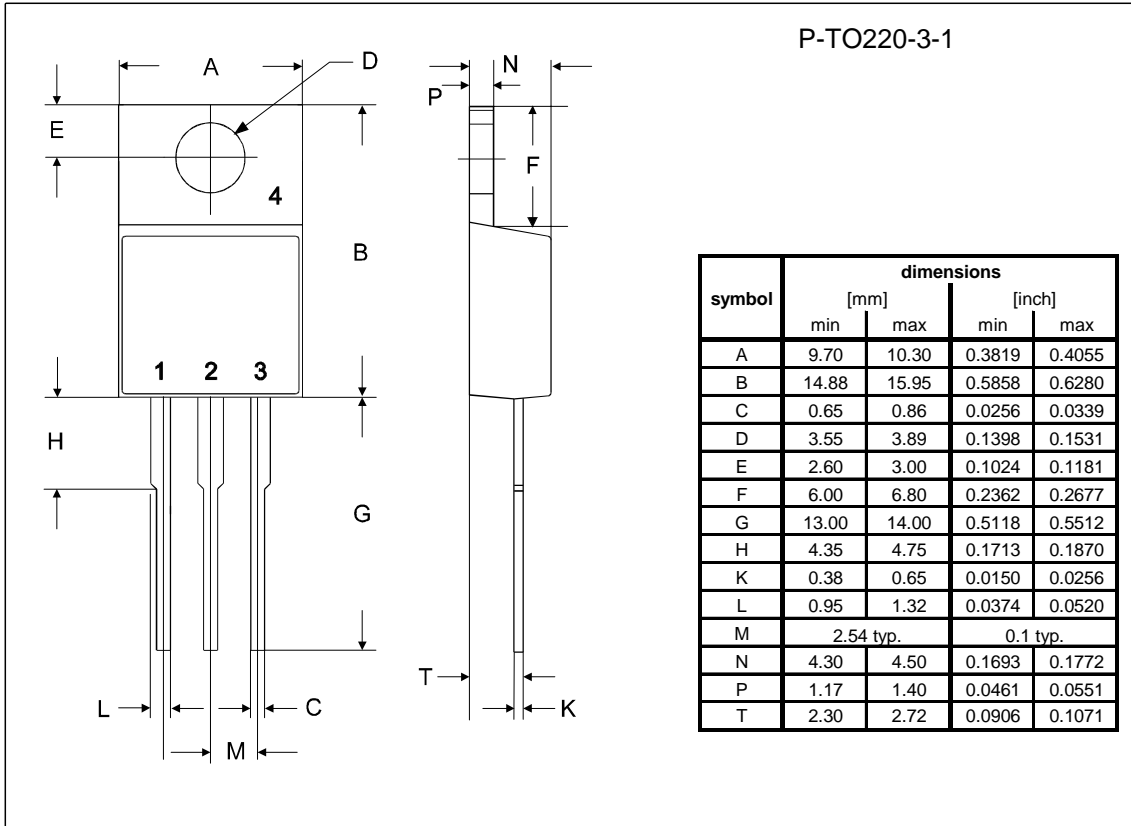
23 Typ. C_{oss} stored energy

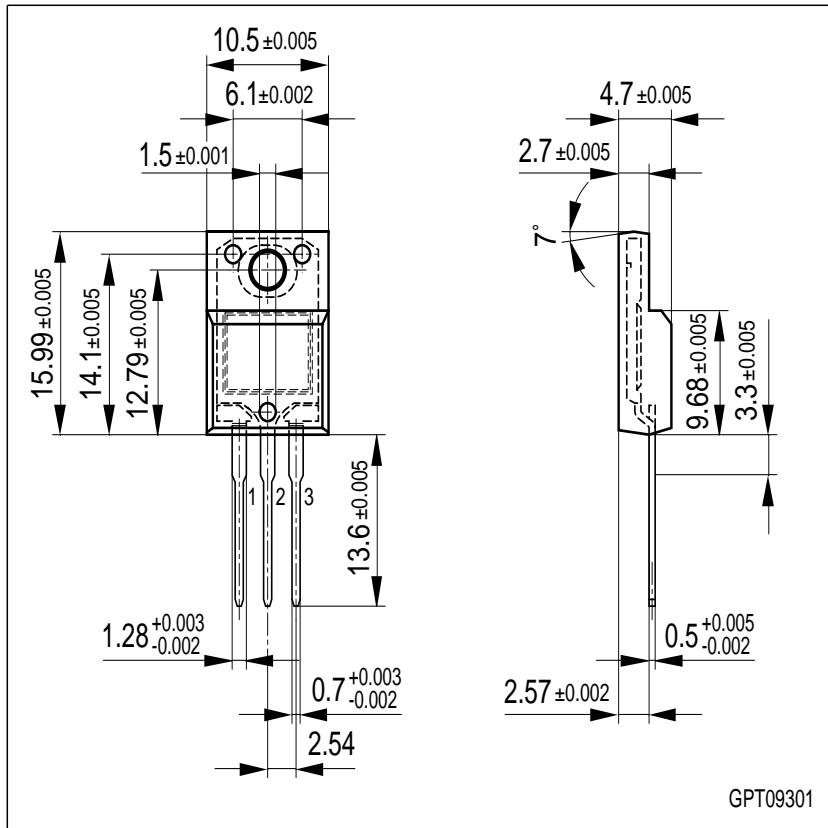
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics







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



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Infineon Technologies AG,
Bereichs Kommunikation
St.-Martin-Strasse 53,
D-81541 München
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