

Cool MOS™ Power Transistor

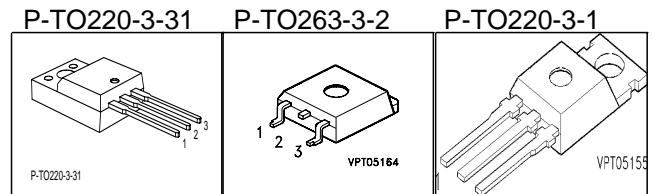
Feature

- New revolutionary high voltage technology
- Worldwide best $R_{DS(on)}$ in TO 220
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances

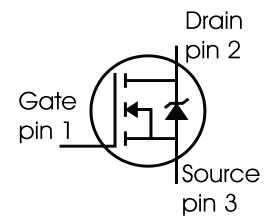
Product Summary

$V_{DS} @ T_{jmax}$	650	V
$R_{DS(on)}$	0.19	Ω
I_D	20	A

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Type	Package	Ordering Code	Marking
SPP20N60C2	P-TO220-3-1	Q67040-S4320	20N60C2
SPB20N60C2	P-TO263-3-2	Q67040-S4322	20N60C2
SPA20N60C2	P-TO220-3-31	Q67040-S4333	20N60C2



Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_B	SPA	
Continuous drain current $T_C = 25\text{ }^\circ\text{C}$ $T_C = 100\text{ }^\circ\text{C}$	I_D	20 13	20 ¹⁾ 13 ¹⁾	A
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	40	40	A
Avalanche energy, single pulse $I_D=10\text{A}, V_{DD}=50\text{V}$	E_{AS}	690	690	mJ
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾ $I_D=20\text{A}, V_{DD}=50\text{V}$	E_{AR}	1	1	
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	20	20	A
Reverse diode dv/dt $I_S = 20\text{ A}, V_{DS} < V_{DD}, di/dt=100\text{A}/\mu\text{s}, T_{jmax}=150^\circ\text{C}$	dv/dt	6	6	V/ns
Gate source voltage	V_{GS}	± 20	± 20	V
Gate source voltage AC ($f > 1\text{Hz}$)	V_{GS}	± 30	± 30	
Power dissipation, $T_C = 25^\circ\text{C}$	P_{tot}	208	34.5	W
Operating and storage temperature	T_j, T_{stg}	-55...+150		$^\circ\text{C}$

Thermal Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Characteristics					
Thermal resistance, junction - case	R_{thJC}	-	-	0.6	K/W
Thermal resistance, junction - case, FullPAK	R_{thJC_FP}	-	-	3.6	
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		-	-	1.67	W/K
Linear derating factor, FullPAK		-	-	0.28	
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, $V_{GS} = V_{DS}$ $I_D=1mA$	$V_{GS(th)}$	3.5	4.5	5.5	
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}	-	0.1	1	μA
		-	-	100	
Gate-source leakage current $V_{GS}=20V, V_{DS}=0V$	I_{GSS}	-	-	100	nA
Drain-source on-state resistance $V_{GS}=10V, I_D=13A, T_j=25\text{ °C}$	$R_{DS(on)}$	-	0.16	0.19	Ω
Gate input resistance $f = 1\text{ MHz, open drain}$	R_G	-	0.54	-	

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	

Characteristics

Transconductance	g_{fs}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 13A$	-	12	-	S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$,	-	3000	-	pF
Output capacitance	C_{oss}	$f = 1MHz$	-	1170	-	
Reverse transfer capacitance	C_{rss}		-	28	-	
Effective output capacitance, ⁴⁾ energy related	$C_{o(er)}$	$V_{GS} = 0V$, $V_{DS} = 0V$ to 480V	-	83	-	
Effective output capacitance, ⁵⁾ time related	$C_{o(tr)}$		-	160	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 380V$, $V_{GS} = 0/13V$,	-	21	-	ns
Rise time	t_r	$I_D = 20A$,	-	51	-	
Turn-off delay time	$t_{d(off)}$	$R_G = 3.6\Omega$, $T_J = 125^\circ C$	-	56	84	
Fall time	t_f		-	6	9	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 350V$, $I_D = 20A$	-	21	-	nC
Gate to drain charge	Q_{gd}		-	46	-	
Gate charge total	Q_g	$V_{DD} = 350V$, $I_D = 20A$, $V_{GS} = 0$ to 10V	-	79	103	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 350V$, $I_D = 20A$	-	8	-	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} .

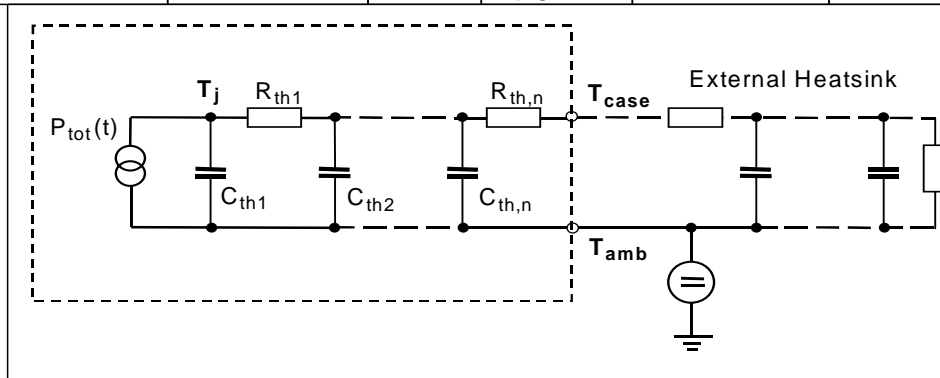
⁵ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
Inverse diode continuous forward current	I_S	$T_C=25^\circ\text{C}$	-	-	20	A
Inverse diode direct current, pulsed	I_{SM}		-	-	40	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}, I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=350\text{V}, I_F=I_S,$	-	610	1040	ns
Reverse recovery charge	Q_{rr}	$di_{rr}/dt=100\text{A}/\mu\text{s}$	-	12	-	μC
Peak reverse recovery current	I_{rrm}		-	48	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^\circ\text{C}$	-	1500	-	$\text{A}/\mu\text{s}$

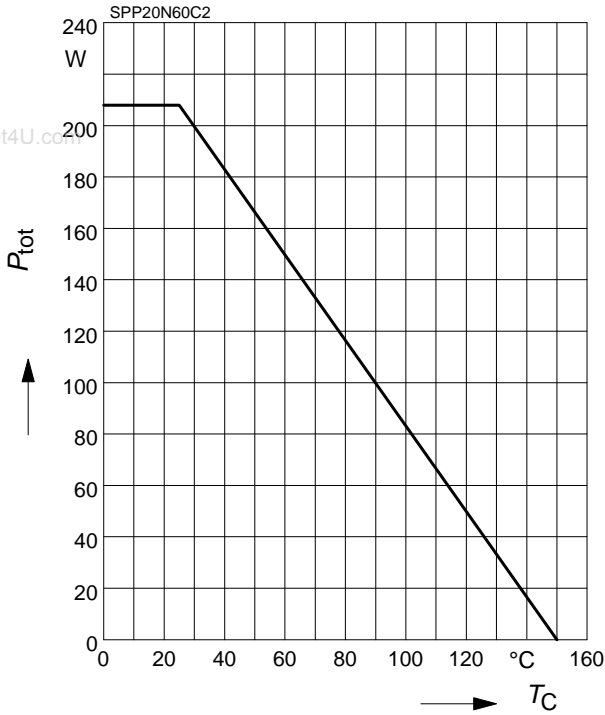
Typical Transient Thermal Characteristics

Symbol	Value		Unit	Symbol	Value		Unit
	SPP_B	SPA			SPP_B	SPA	
R_{th1}	0.007416	0.077	K/W	C_{th1}	0.0004409	0.000376	Ws/K
R_{th2}	0.016	0.015		C_{th2}	0.001462	0.00141	
R_{th3}	0.021	0.022		C_{th3}	0.0024	0.00192	
R_{th4}	0.06	0.063		C_{th4}	0.003031	0.00332	
R_{th5}	0.083	0.214		C_{th5}	0.02	0.019	
R_{th6}	0.038	2.479		C_{th6}	0.146	0.412	



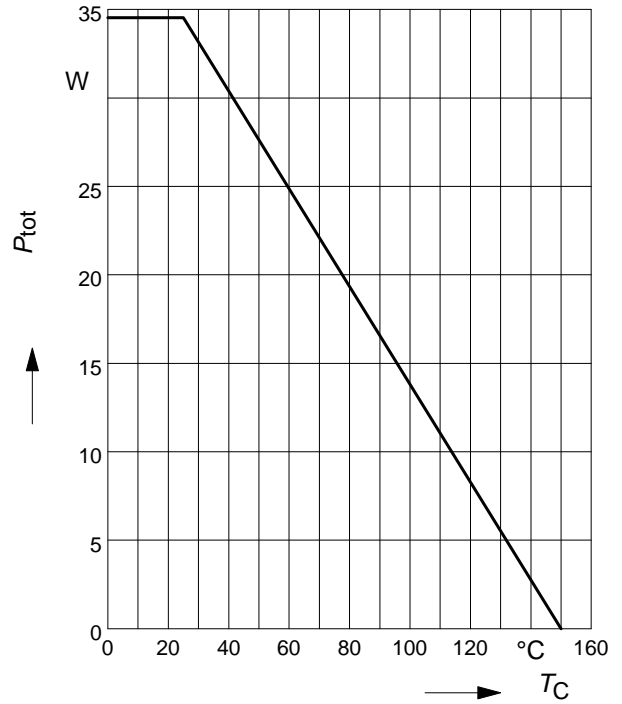
1 Power dissipation

$P_{tot} = f(T_C)$



2 Power dissipation FullPAK

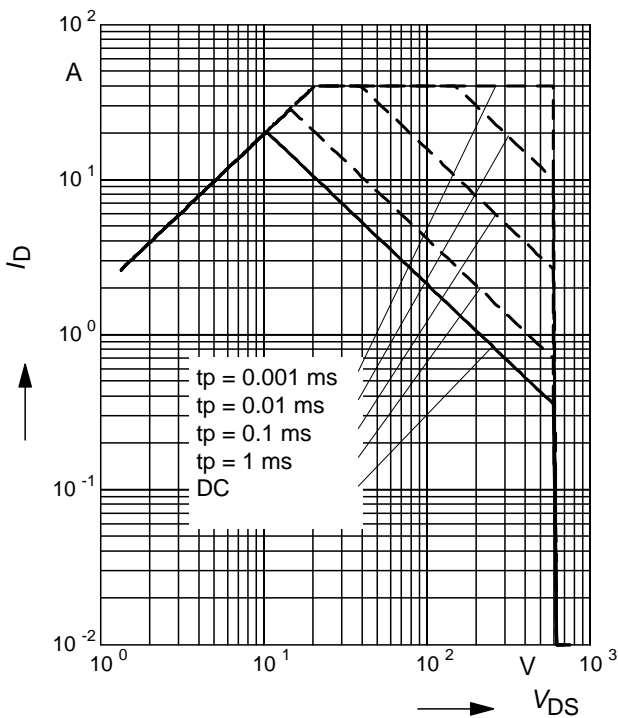
$P_{tot} = f(T_C)$



3 Safe operating area

$I_D = f(V_{DS})$

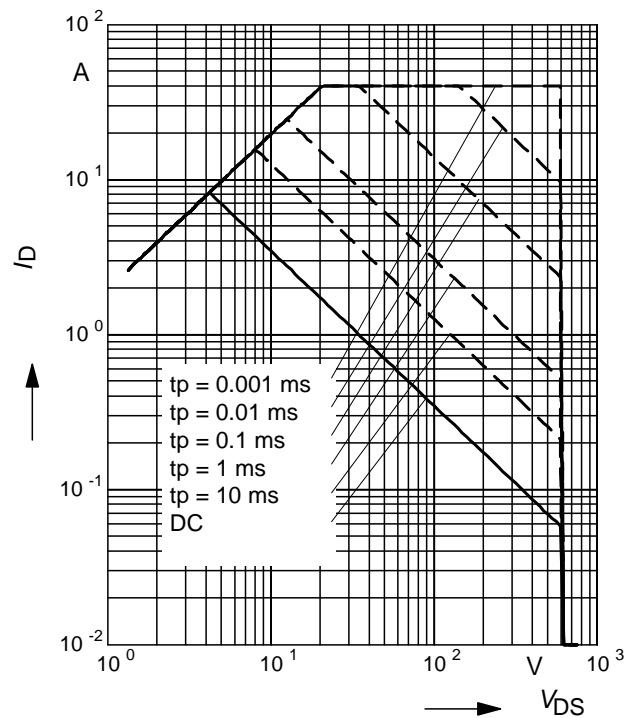
parameter : $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

$I_D = f(V_{DS})$

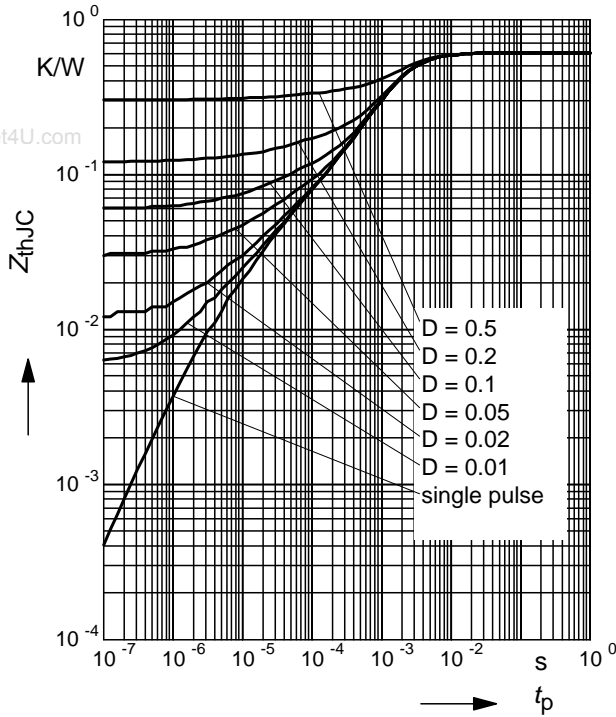
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

$Z_{thJC} = f(t_p)$

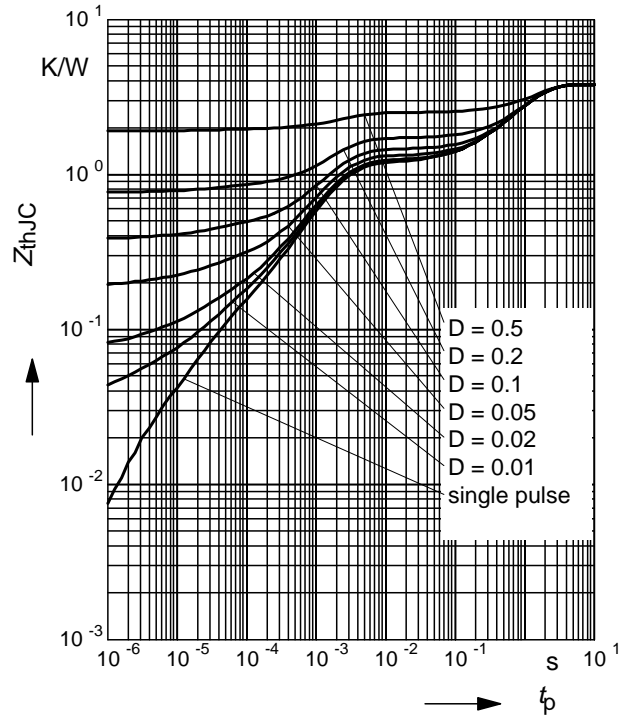
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

$Z_{thJC} = f(t_p)$

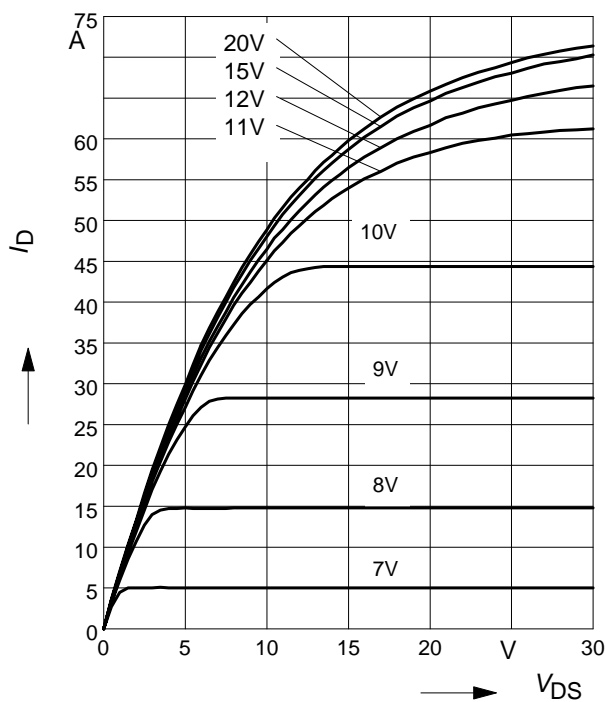
parameter: $D = t_p/t$



7 Typ. output characteristic

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

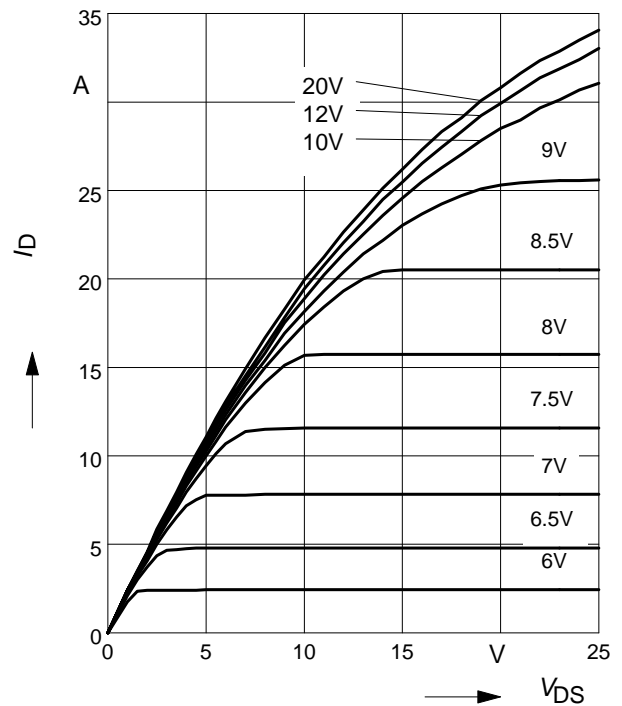
parameter: $t_p = 10 \mu s, V_{GS}$



8 Typ. output characteristic

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

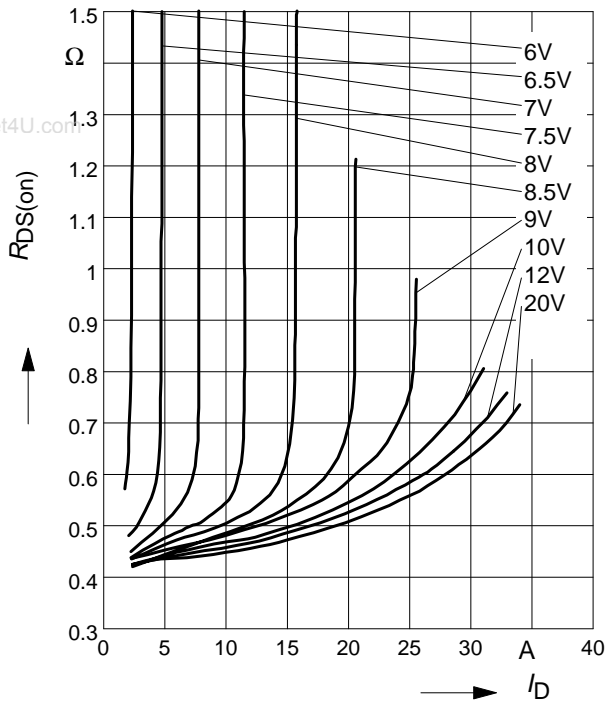
parameter: $t_p = 10 \mu s, V_{GS}$



9 Typ. drain-source on resistance

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

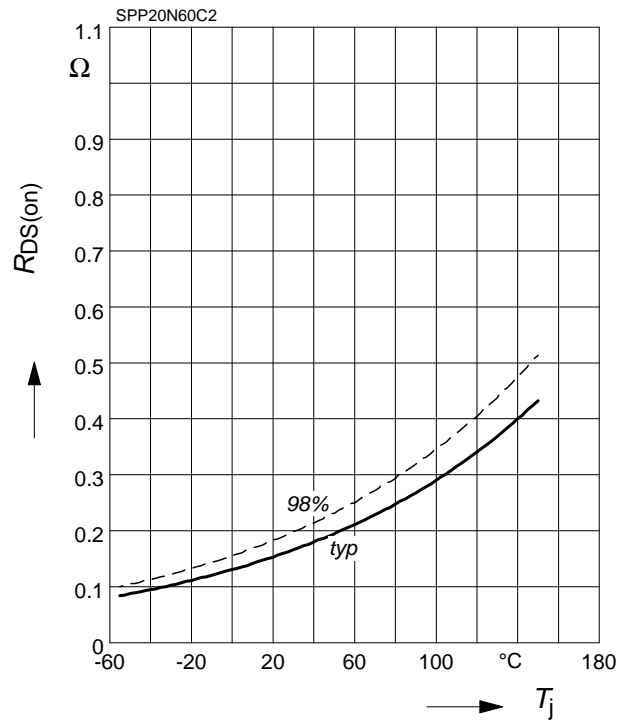
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

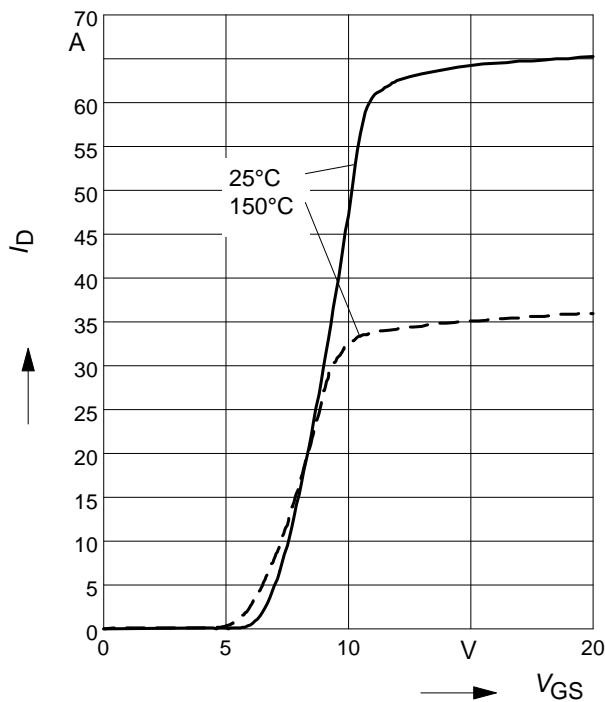
parameter: $I_D = 13\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

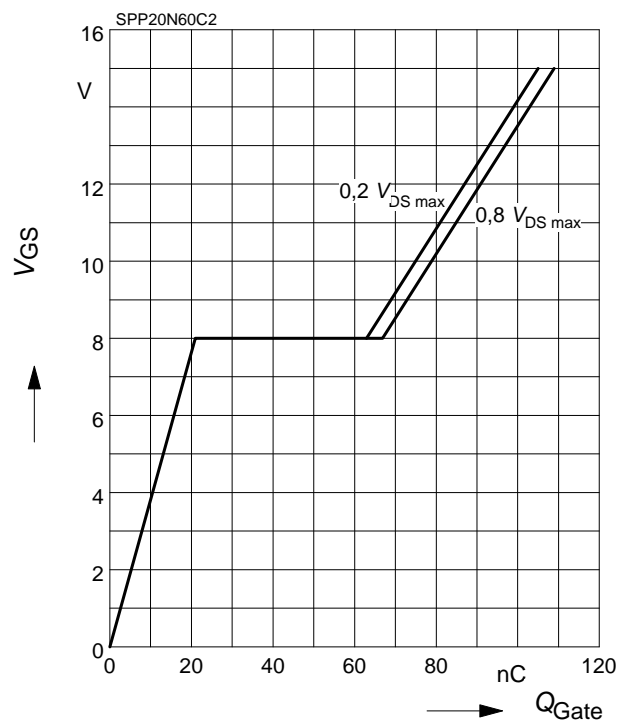
parameter: $t_p = 10\ \mu\text{s}$



12 Typ. gate charge

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

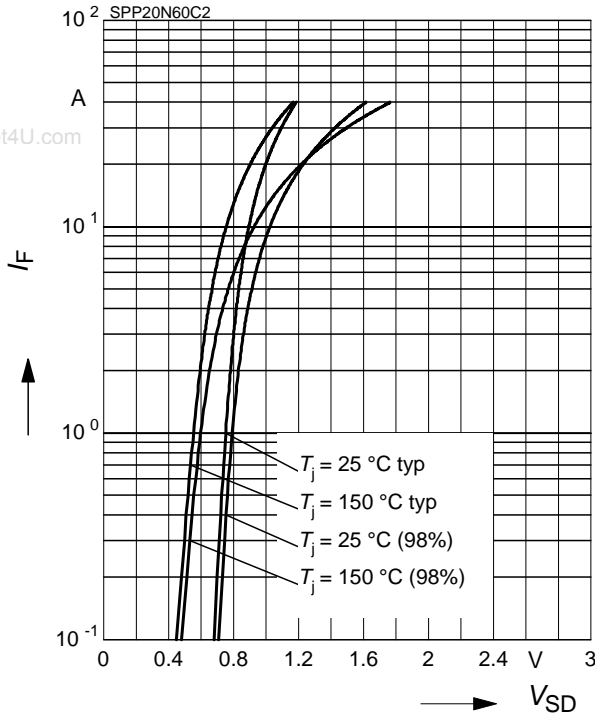
parameter: $I_D = 20\text{ A pulsed}$



13 Forward characteristics of body diode

$I_F = f(V_{SD})$

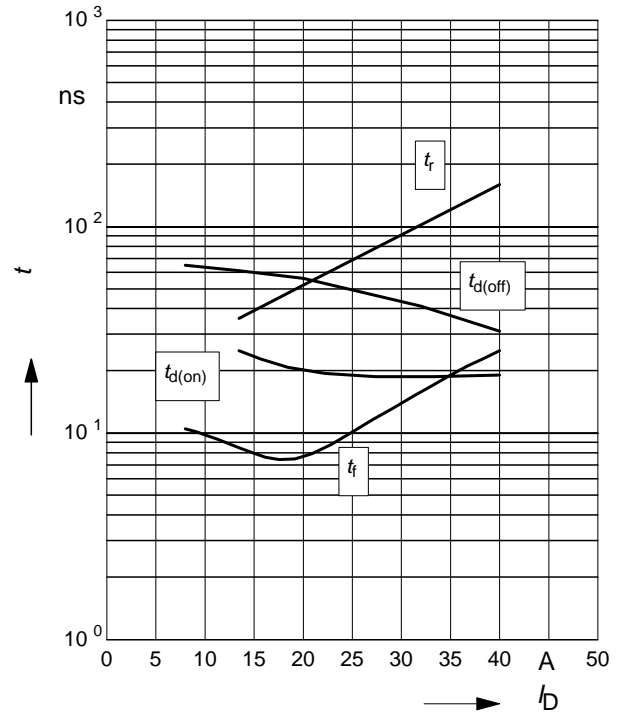
parameter: $T_j = 10 \mu s$



14 Typ. switching time

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

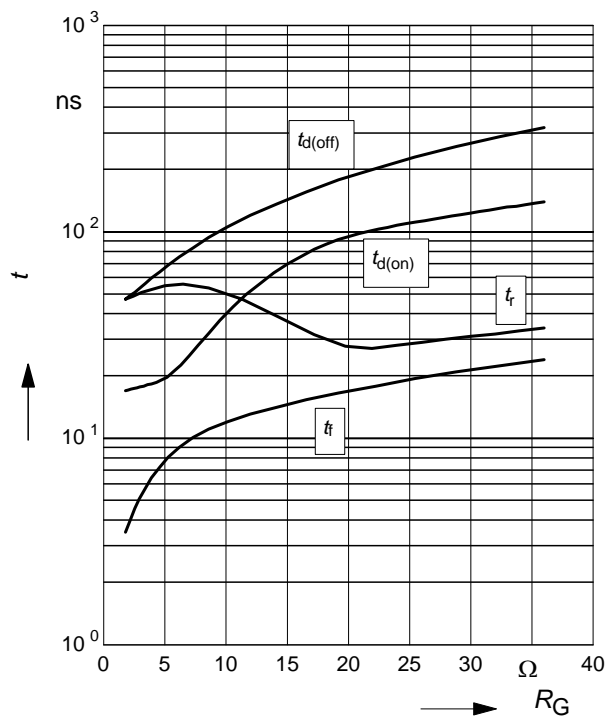
par.: $V_{DS} = 380V, V_{GS} = 0/+13V, R_G = 3.6\Omega$



15 Typ. switching time

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

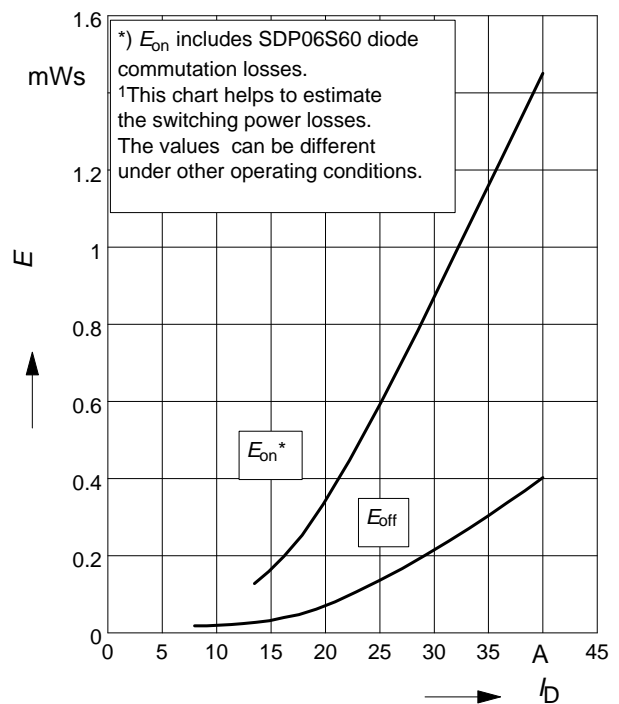
par.: $V_{DS} = 380V, V_{GS} = 0/+13V, I_D = 20A$



16 Typ. switching losses¹⁾

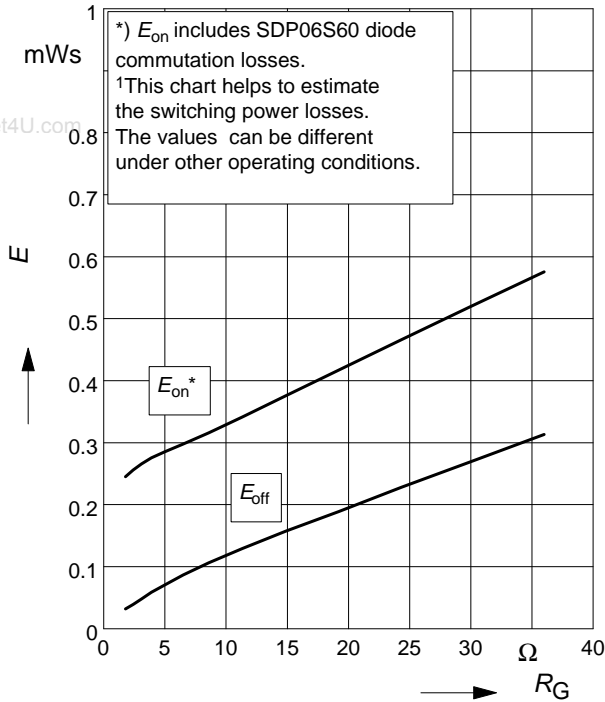
$E = f(I_D)$, inductive load, $T_j = 125^\circ C$

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



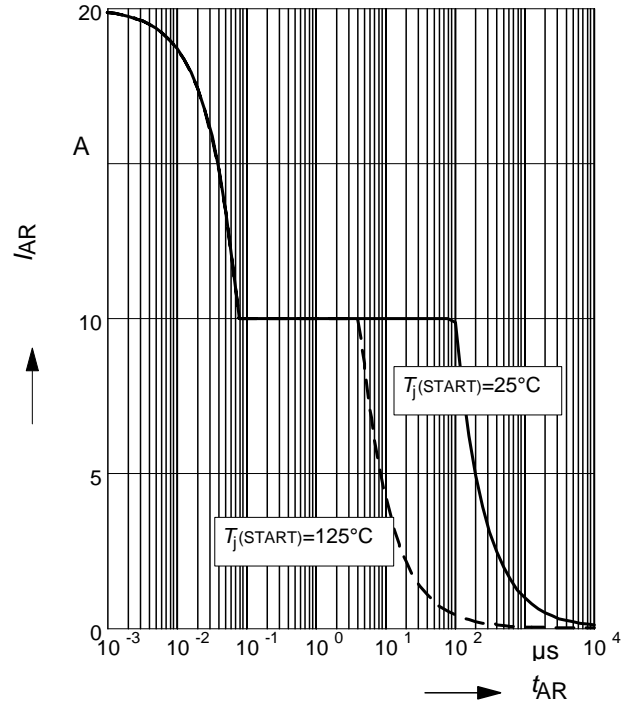
17 Typ. switching losses¹⁾

$E = f(R_G)$, inductive load, $T_j=125^\circ\text{C}$
par.: $V_{DS}=380\text{V}$, $V_{GS}=0/+13\text{V}$, $I_D=20\text{A}$



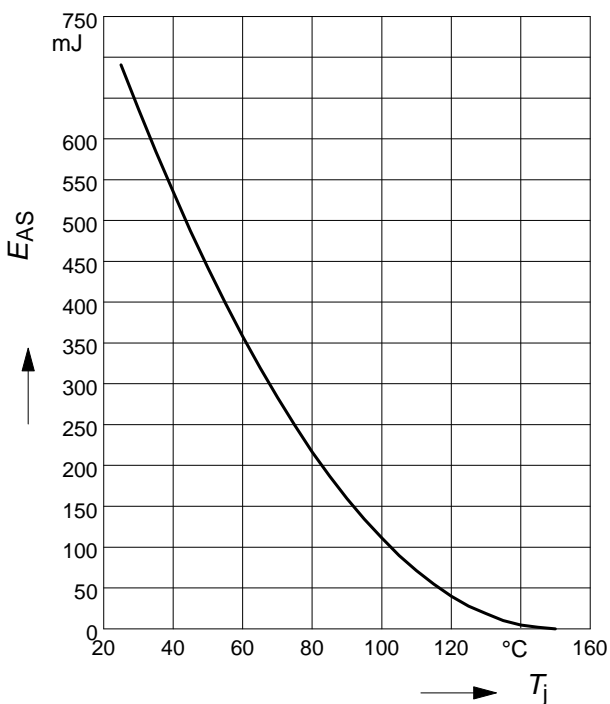
18 Avalanche SOA

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



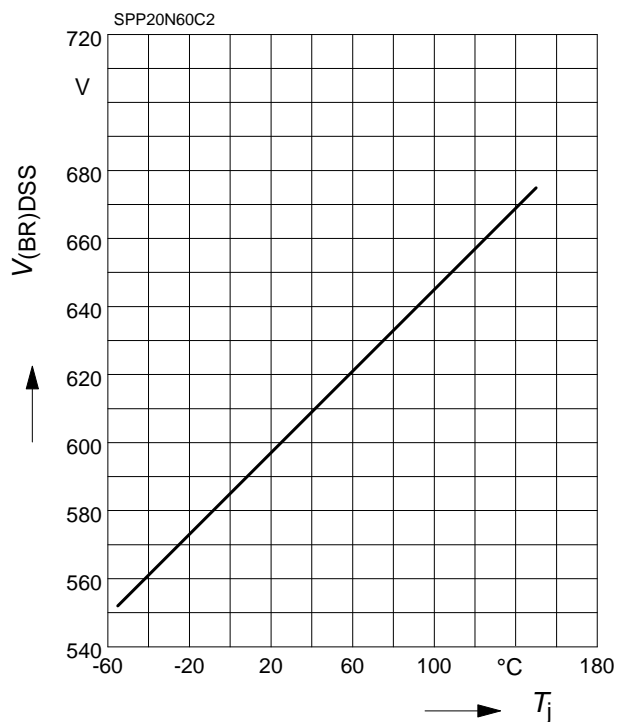
19 Avalanche energy

$E_{AS} = f(T_j)$
par.: $I_D = 10\text{A}$, $V_{DD} = 50\text{V}$



20 Drain-source breakdown voltage

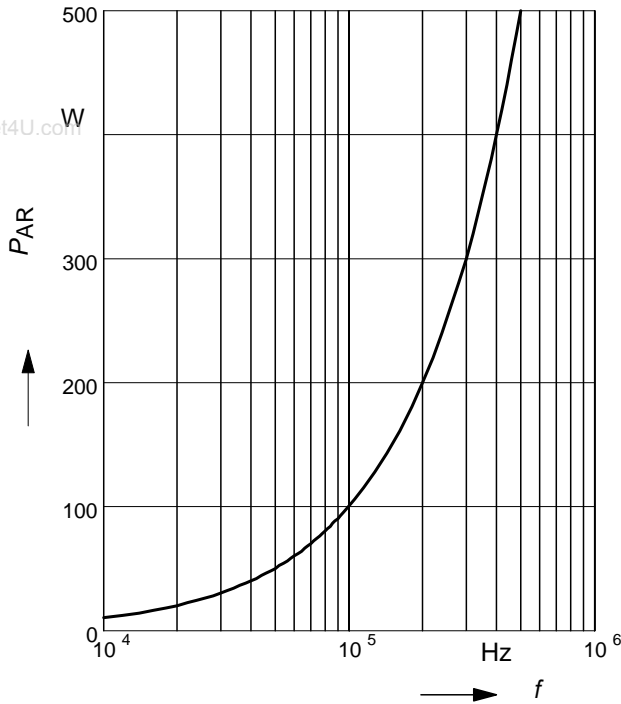
$V_{(BR)DSS} = f(T_j)$



21 Avalanche power losses

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

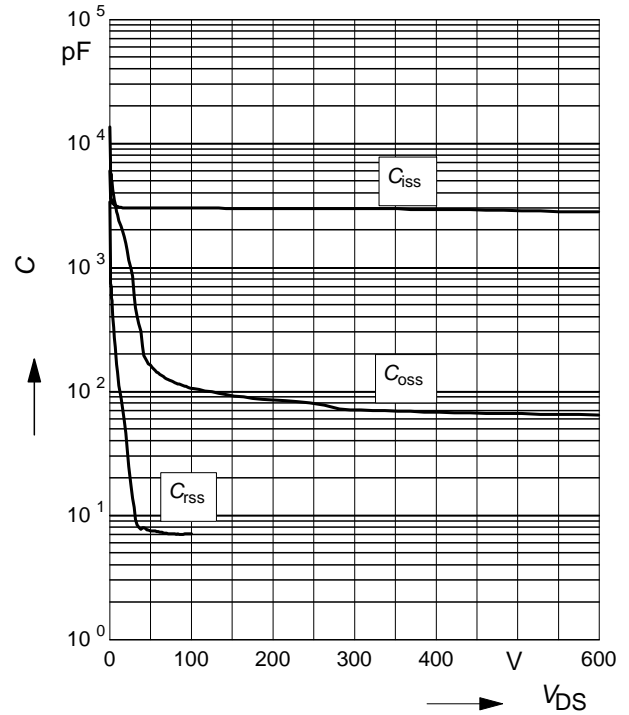
parameter: $E_{AR}=1\text{mJ}$



22 Typ. capacitances

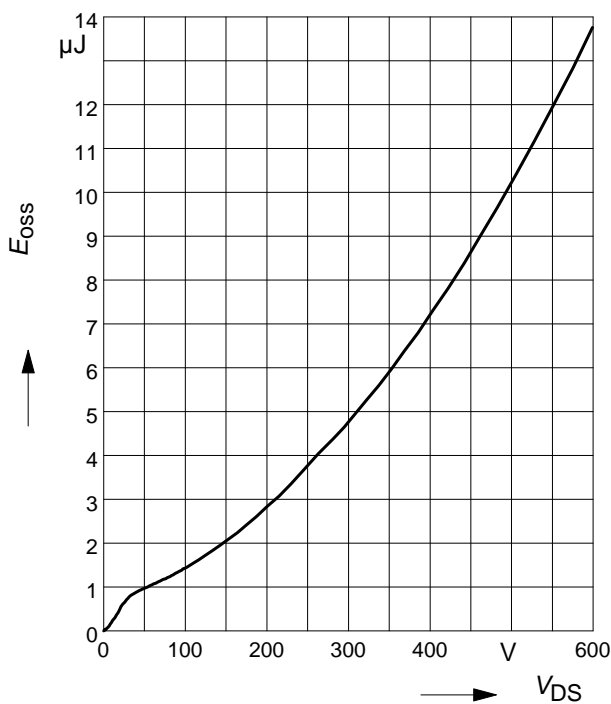
$$C = f(V_{DS})$$

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

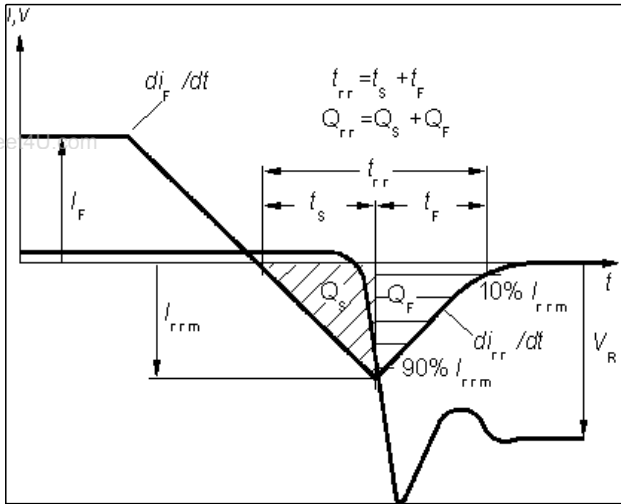


23 Typ. C_{oss} stored energy

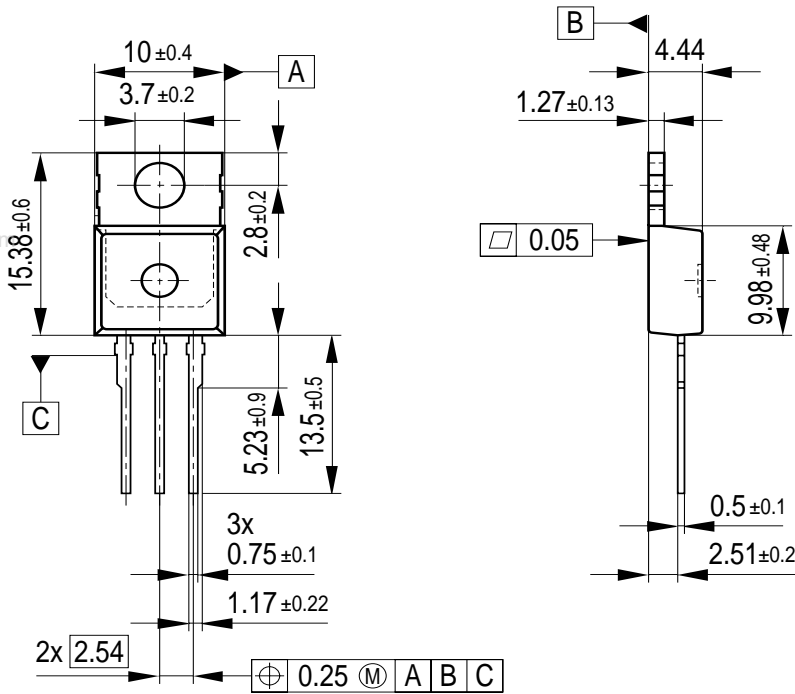
$$E_{oss} = f(V_{DS})$$



Definition of diodes switching characteristics

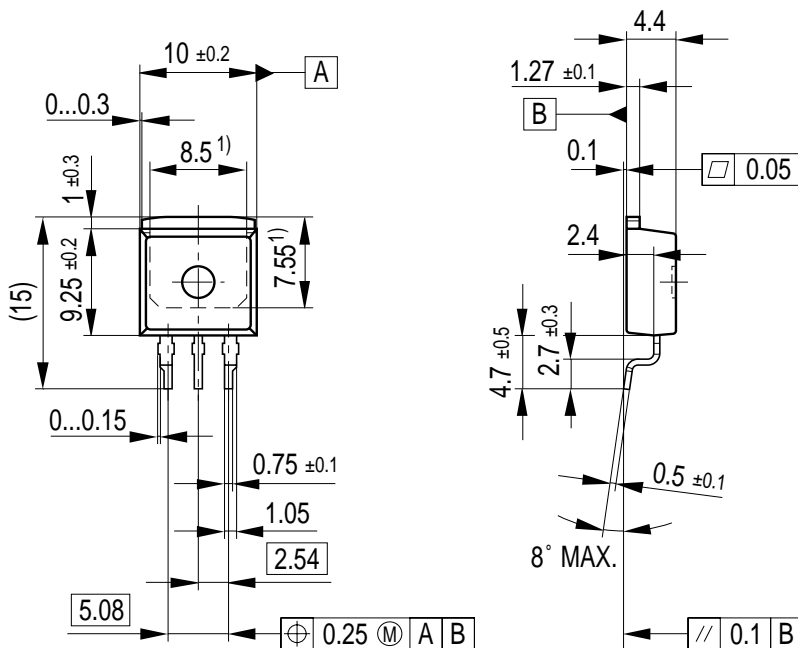


P-TO-220-3-1



All metal surfaces tin plated, except area of cut.
Metal surface min. $x=7.25$, $y=12.3$

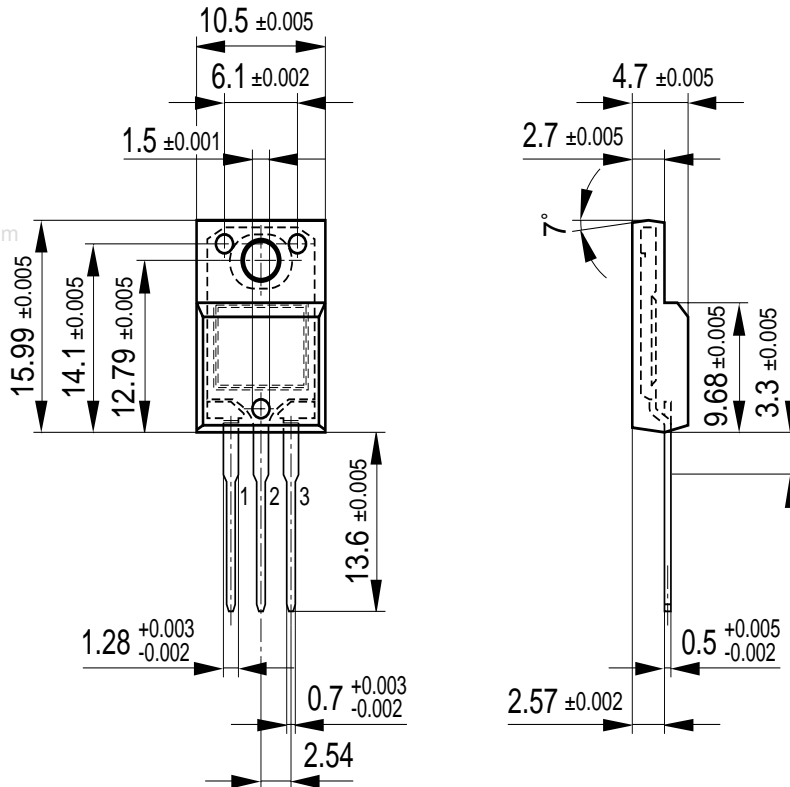
P-TO-263-3-1 (D²-PAK)



¹⁾ Typical

All metal surfaces: tin plated, except area of cut.
Metal surface min. $x=7.25$, $y=6.9$

P-TO-220-3-31 (FullPAK)



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

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