

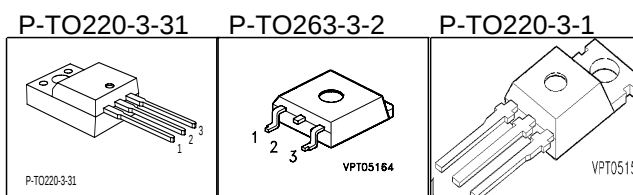
Cool MOS™ Power Transistor

Feature

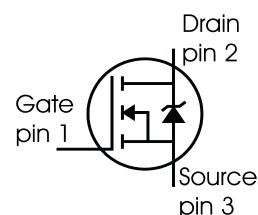
- New revolutionary high voltage technology
- Ultra low gate charge
- Periodic avalanche rated
- Extreme dv/dt rated
- Ultra low effective capacitances

Product Summary

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



Type	Package	Ordering Code	Marking
SPP04N60C2	P-TO220-3-1	Q67040-S4304	04N60C2
SPB04N60C2	P-TO263-3-2	Q67040-S4305	04N60C2
SPA04N60C2	P-TO220-3-31	Q67040-S4330	04N60C2



Maximum Ratings

Parameter	Symbol	Value		Unit
		SPP_B	SPA	
Continuous drain current	I_D			A
$T_C = 25\text{ °C}$		4.5	4.5 ¹⁾	
$T_C = 100\text{ °C}$		2.8	2.8 ¹⁾	
Pulsed drain current, t_p limited by T_{jmax}	$I_{D\text{ puls}}$	9	9	A
Avalanche energy, single pulse	E_{AS}	130	130	mJ
$I_D=3.6\text{ A}$, $V_{DD}=50\text{ V}$				
Avalanche energy, repetitive t_{AR} limited by T_{jmax} ²⁾	E_{AR}	0.4	0.4	
$I_D=4.5\text{ A}$, $V_{DD}=50\text{ V}$				
Avalanche current, repetitive t_{AR} limited by T_{jmax}	I_{AR}	4.5	4.5	A
Reverse diode dv/dt	dv/dt	6	6	V/ns
$I_S = 4.5\text{ A}$, $V_{DS} < V_{DD}$, di/dt=100A/μs, $T_{jmax}=150\text{ °C}$				
Gate source voltage	V_{GS}	±20	±20	V
Gate source voltage AC (f >1Hz)	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	$R_{thJC \text{ FP}}$	-	-	4	
Thermal resistance, junction - ambient, leaded	R_{thJA}	-	-	62	
Thermal resistance, junction - ambient, FullPAK	$R_{thJA \text{ FP}}$	-	-	80	
SMD version, device on PCB: @ min. footprint @ 6 cm ² cooling area ³⁾	R_{thJA}	- -	- 35	62 -	
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 $T_j = 25^\circ\text{C}$, unless otherwise specified

Static Characteristics

Drain-source breakdown voltage $V_{GS}=0\text{V}$, $I_D=0.25\text{mA}$	$V_{(BR)DSS}$	600	-	-	V
Drain-source avalanche breakdown voltage $V_{GS}=0\text{V}$, $I_D=4.5\text{A}$	$V_{(BR)DS}$	-	700	-	
Gate threshold voltage, $V_{GS} = V_{DS}$ $I_D=200\mu\text{A}$, $T_j=25^\circ\text{C}$	$V_{GS(th)}$	3.5	4.5	5.5	
Zero gate voltage drain current $V_{DS} = 600\text{V}$, $V_{GS} = 0\text{V}$, $T_j = 25^\circ\text{C}$ $V_{DS} = 600\text{V}$, $V_{GS} = 0\text{V}$, $T_j = 150^\circ\text{C}$	I_{DSS}	- -	0.5 -	1 50	μA
Gate-source leakage current $V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$	I_{GSS}	-	-	100	
Drain-source on-state resistance $V_{GS}=10\text{V}$, $I_D=2.8\text{A}$, $T_j=25^\circ\text{C}$	$R_{DS(on)}$	-	0.85	0.95	Ω
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}	$V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$, $I_D = 2.8A$	-	2.5		S
Input capacitance	C_{iss}	$V_{GS} = 0V$, $V_{DS} = 25V$, $f = 1MHz$	-	580	-	pF
Output capacitance	C_{oss}		-	220	-	
Reverse transfer capacitance	C_{rss}		-	7	-	
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	$t_{d(on)}$	$V_{DD} = 380V$, $V_{GS} = 0/13V$, $I_D = 4.5A$, $R_G = 18\Omega$, $T_j = 125^\circ C$	-	10	-	ns
Rise time	t_r		-	31	-	
Turn-off delay time	$t_{d(off)}$		-	44	66	
Fall time	t_f		-	12.5	18.8	

Gate Charge Characteristics

Gate to source charge	Q_{gs}	$V_{DD} = 350V$, $I_D = 4.5A$	-	4.5	-	nC
Gate to drain charge	Q_{gd}		-	11	-	
Gate charge total	Q_g	$V_{DD} = 350V$, $I_D = 4.5A$, $V_{GS} = 0$ to $10V$	-	17.6	22.9	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} = 350V$, $I_D = 4.5A$	-	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} .

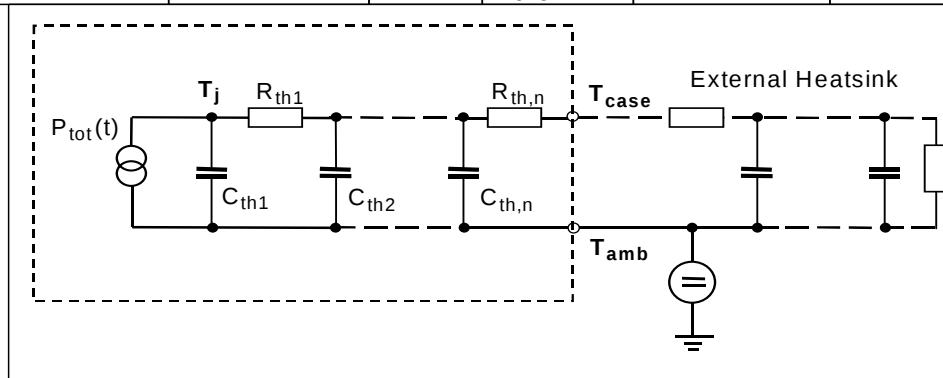
⁵ $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

Electrical Characteristics

Parameter	Symbol	Conditions	Values			Unit
			min.	typ.	max.	
Characteristics						
Inverse diode continuous forward current	I_S	$T_C=25^{\circ}\text{C}$	-	-	4.5	A
Inverse diode direct current, pulsed	I_{SM}		-	-	9	
Inverse diode forward voltage	V_{SD}	$V_{GS}=0\text{V}$, $I_F=I_S$	-	1	1.2	V
Reverse recovery time	t_{rr}	$V_R=350\text{V}$, $I_F=I_S$, $di_F/dt=100\text{A}/\mu\text{s}$	-	900	1530	ns
Reverse recovery charge	Q_{rr}		-	3.2	-	μC
Peak reverse recovery current	I_{rrm}		-	12	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j=25^{\circ}\text{C}$	-	440	-	$\text{A}/\mu\text{s}$

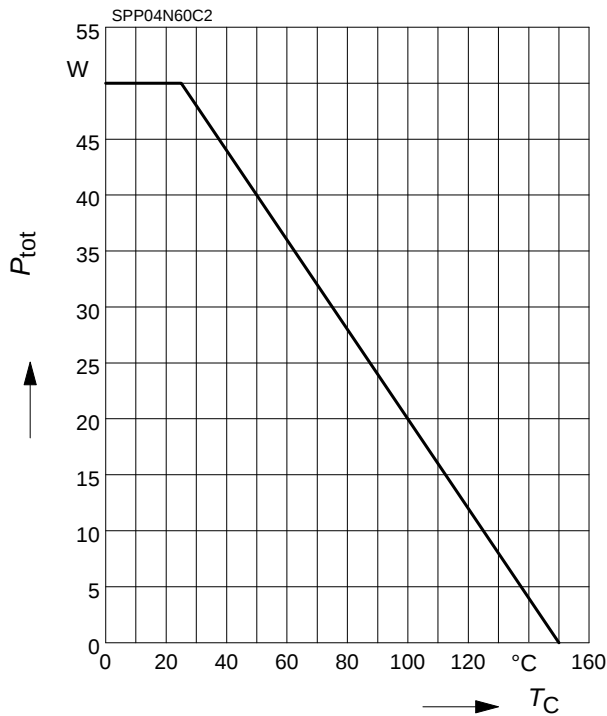
Typical Transient Thermal Characteristics

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}	0.101	0.102		C_{th3}	0.0004859	0.000401	
R_{th4}	0.262	0.27		C_{th4}	0.0006523	0.000736	
R_{th5}	0.294	0.594		C_{th5}	0.005017	0.00501	
R_{th6}	0.094	2.536		C_{th6}	0.052	0.412	



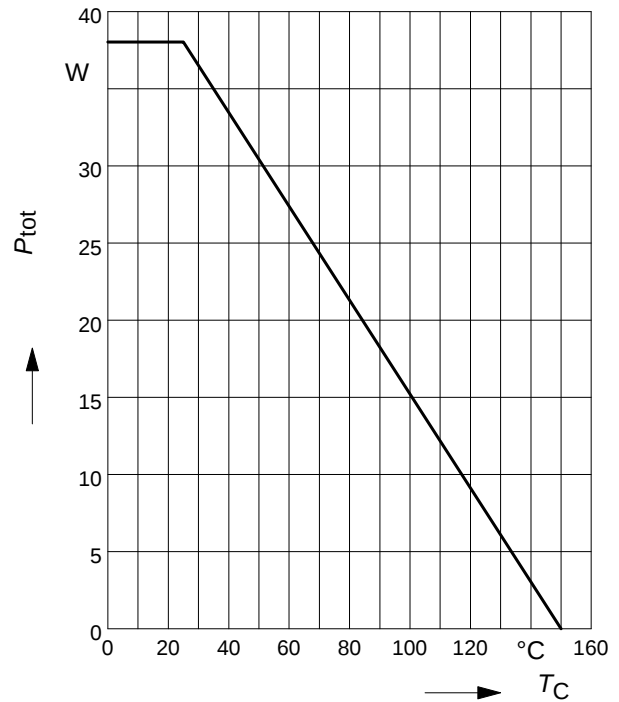
1 Power dissipation

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



2 Power dissipation FullPAK

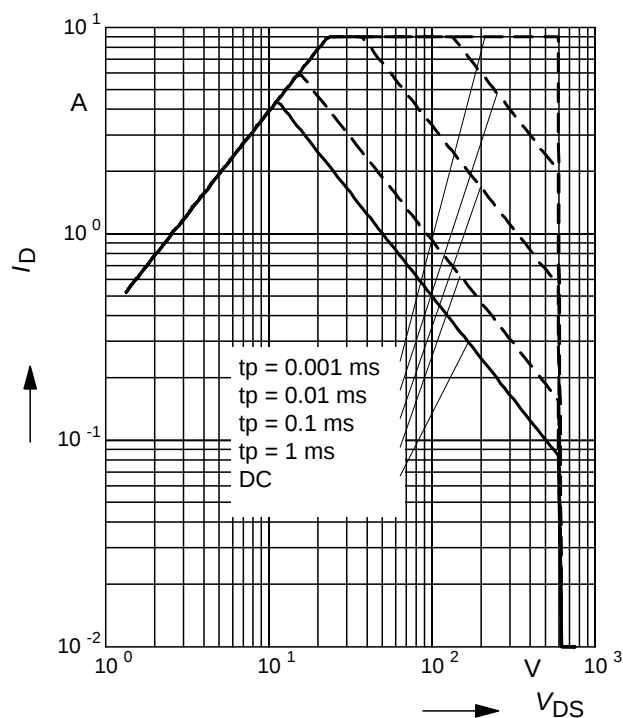
$$P_{\text{tot}} = f(T_C)$$



3 Safe operating area

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

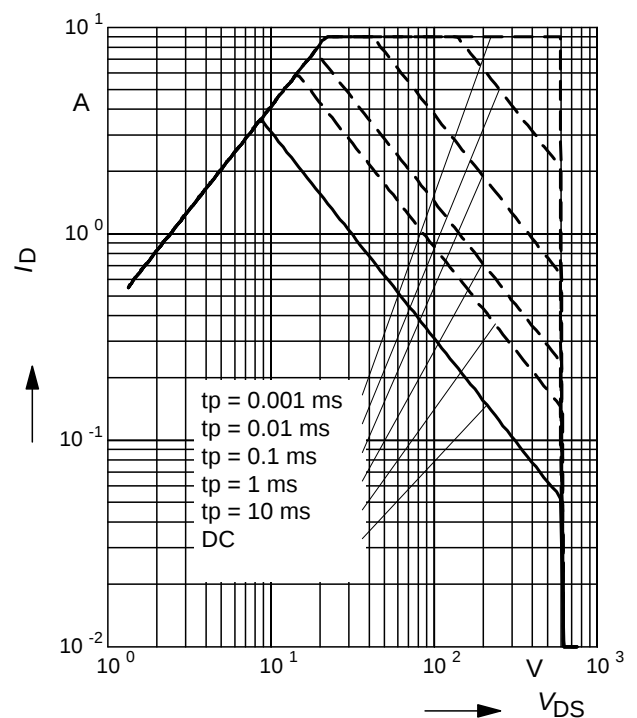
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



4 Safe operating area FullPAK

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

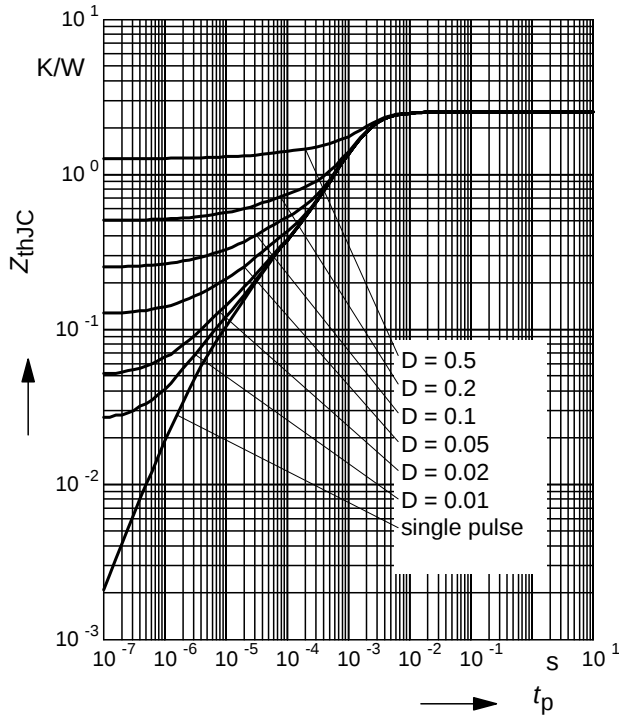
parameter: $D = 0$, $T_C = 25^\circ\text{C}$



5 Transient thermal impedance

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

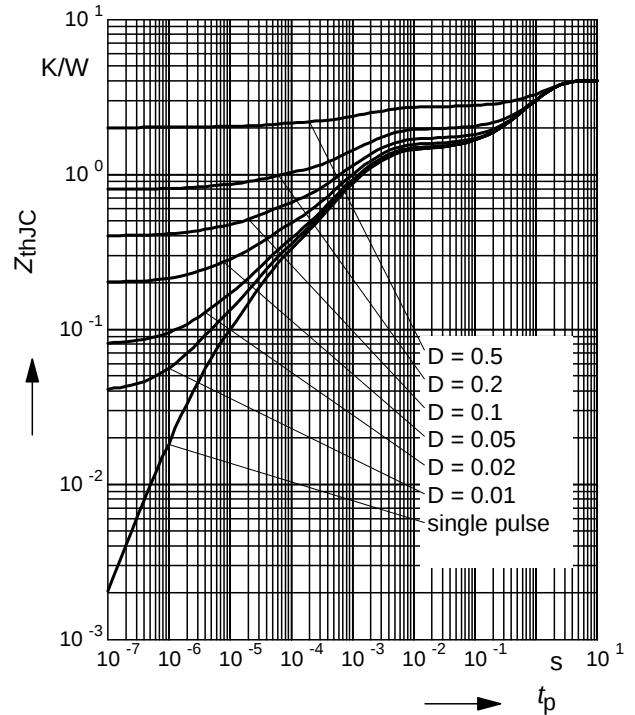
parameter: $D = t_p/T$



6 Transient thermal impedance FullPAK

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

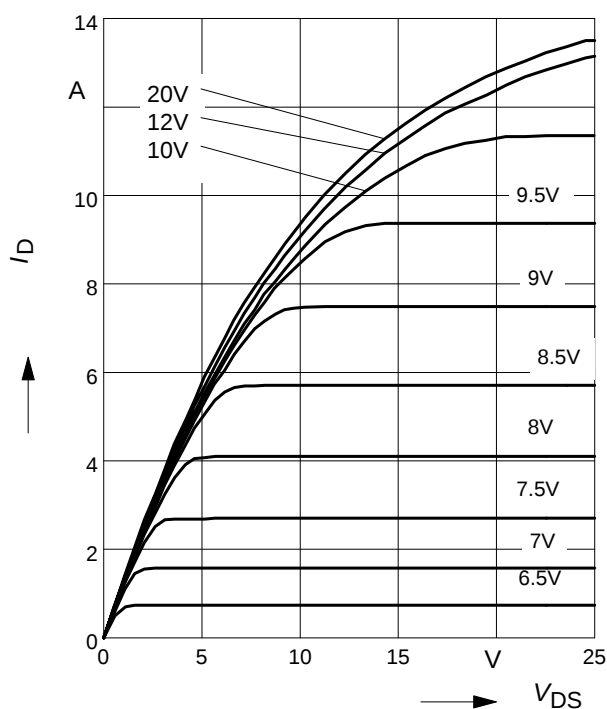
parameter: $D = t_p/t$



7 Typ. output characteristic

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

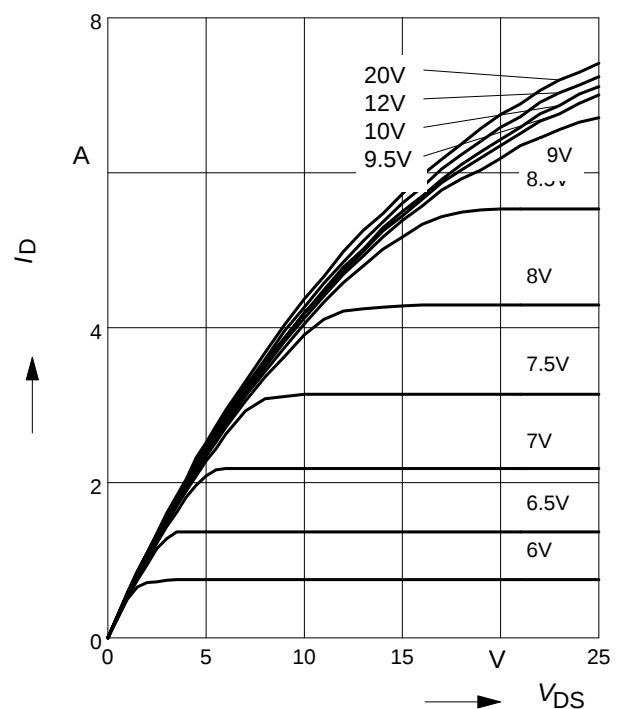
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



8 Typ. output characteristic

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

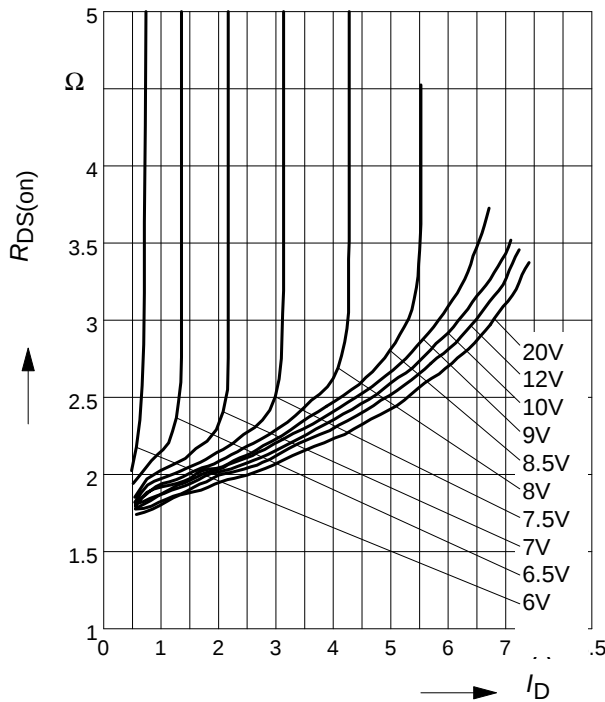
parameter: $t_p = 10 \mu\text{s}, V_{GS}$



9 Typ. drain-source on resistance

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

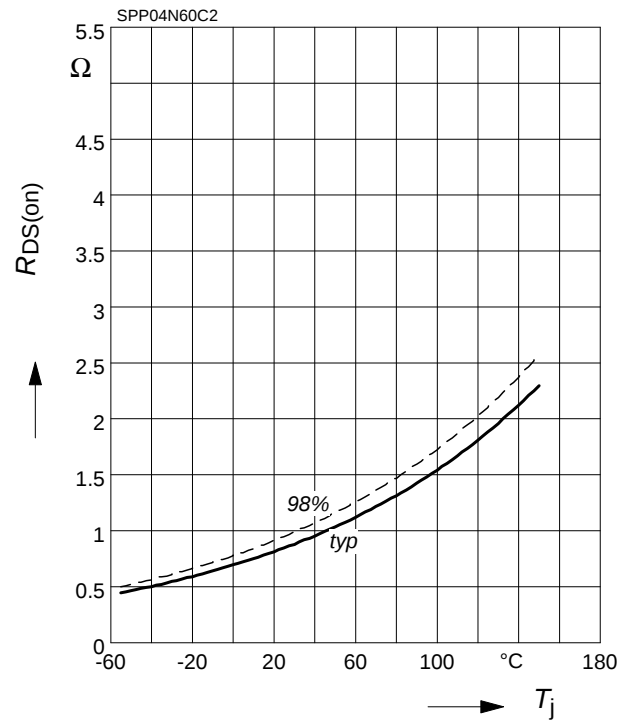
parameter: $T_j = 150^\circ\text{C}$, V_{GS}



10 Drain-source on-state resistance

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

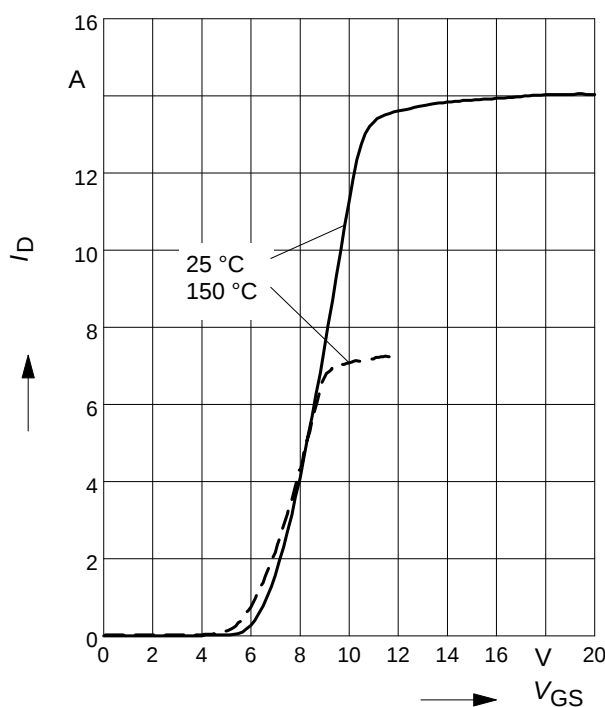
parameter: $I_D = 2.8\text{ A}$, $V_{GS} = 10\text{ V}$



11 Typ. transfer characteristics

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

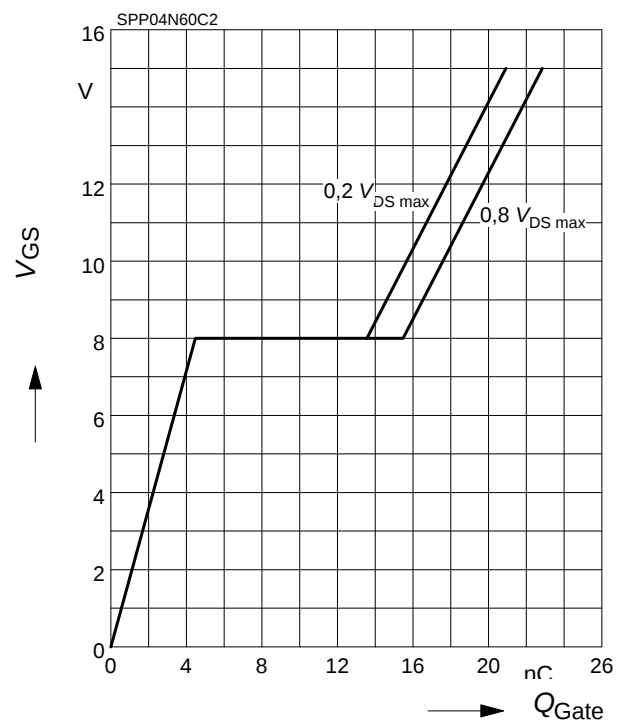
parameter: $t_p = 10\text{ }\mu\text{s}$



12 Typ. gate charge

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

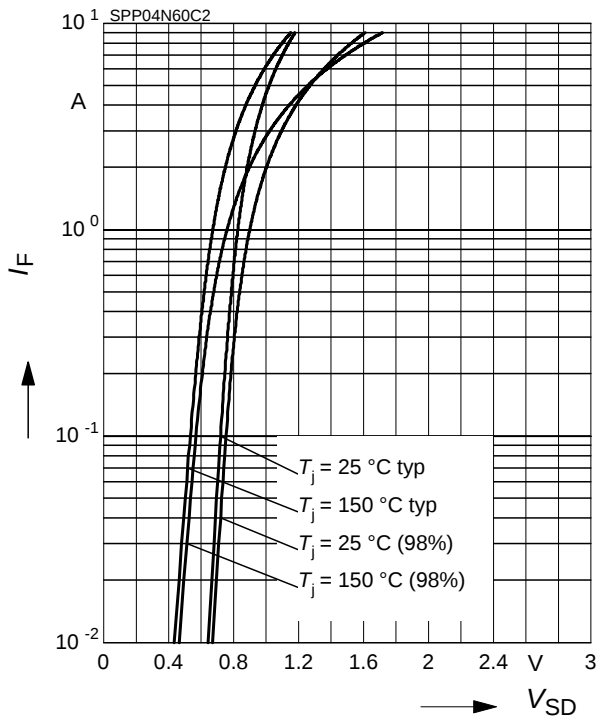
parameter: $I_D = 4.5\text{ A}$ pulsed



13 Forward characteristics of body diode

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

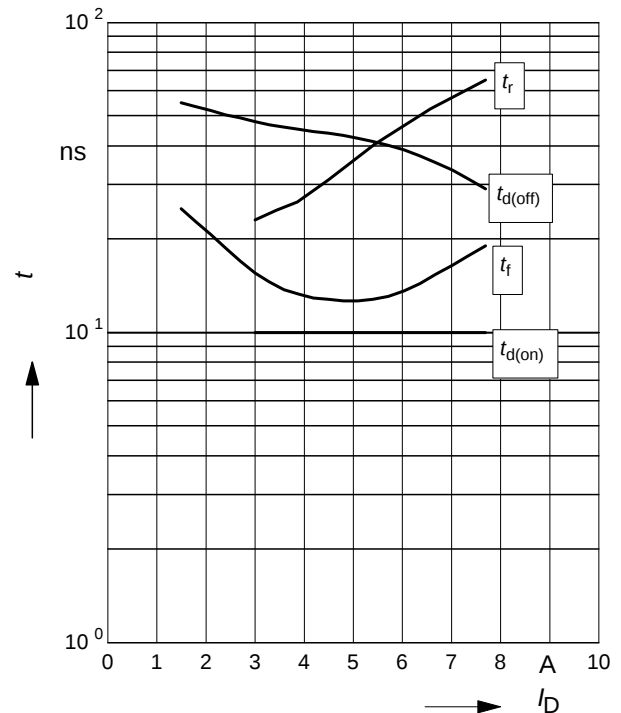
parameter: T_j , $t_p = 10 \mu s$



14 Typ. switching time

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

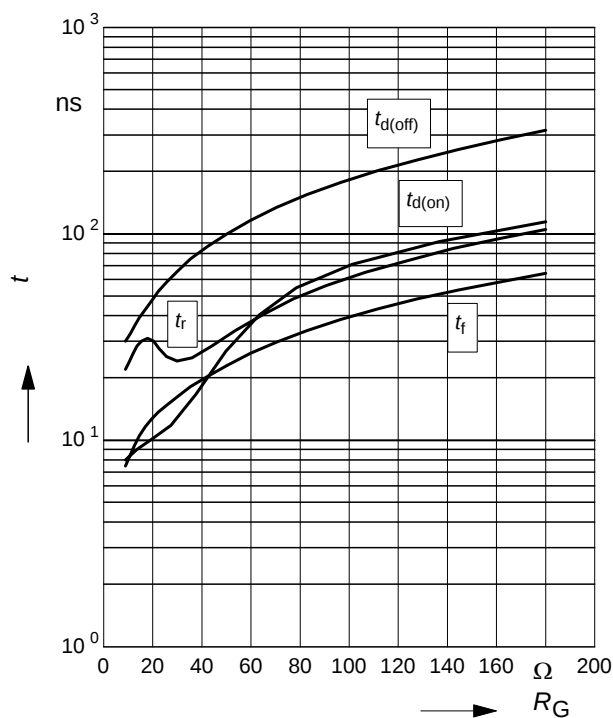
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $R_G = 18\Omega$



15 Typ. switching time

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

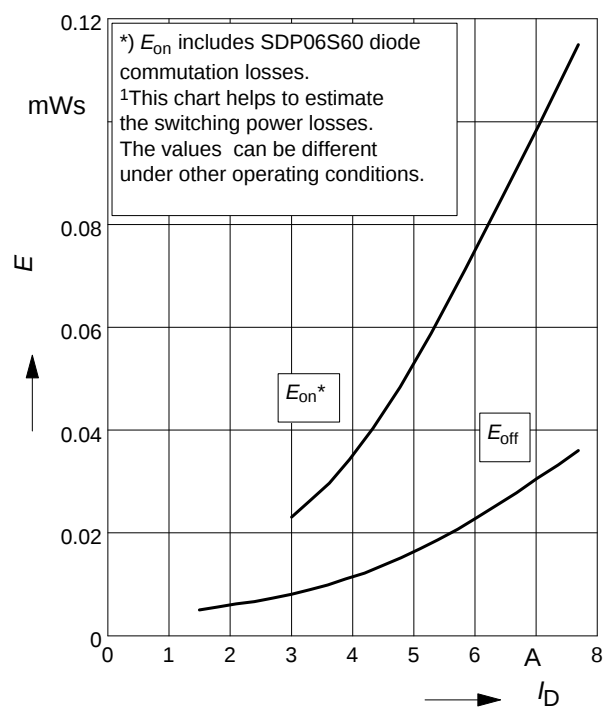
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $I_D = 4.5 A$



16 Typ. switching losses¹⁾

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

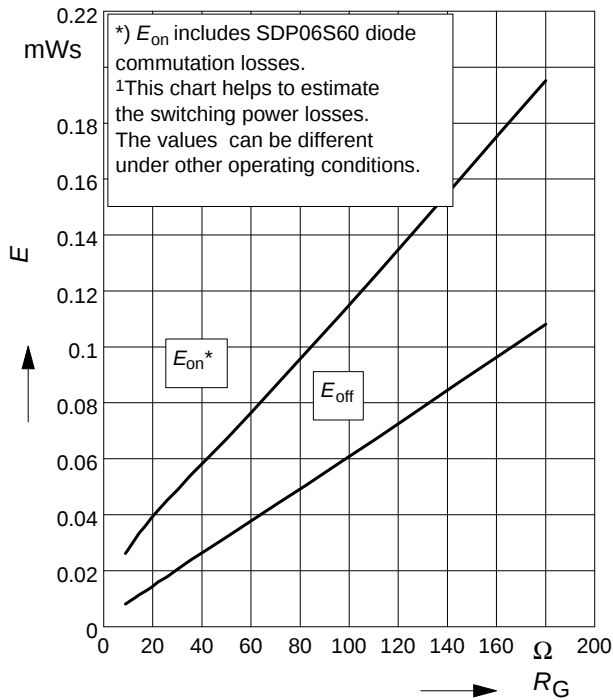
par.: $V_{DS} = 380V$, $V_{GS} = 0/+13V$, $R_G = 18\Omega$



17 Typ. switching losses¹⁾

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

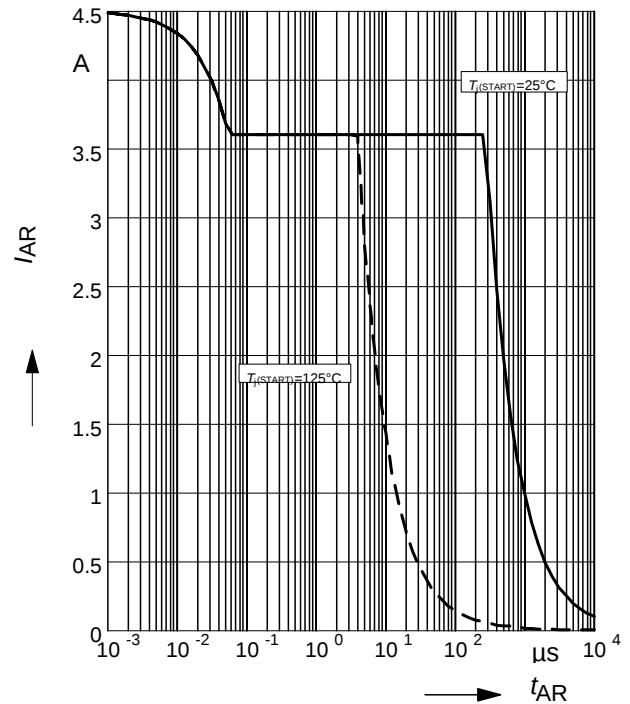
par.: $V_{DS} = 380\text{V}$, $V_{GS} = 0/+13\text{V}$, $I_D = 4.5\text{A}$



18 Avalanche SOA

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

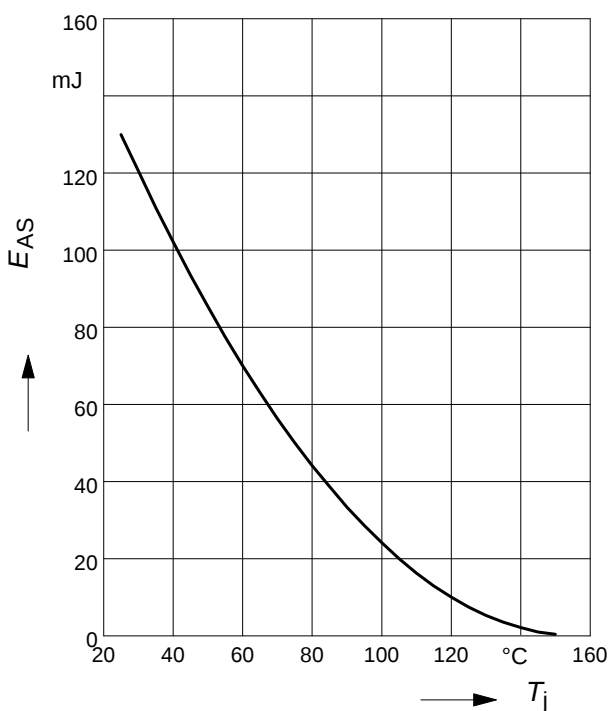
par.: $T_j \leq 150^\circ\text{C}$



19 Avalanche energy

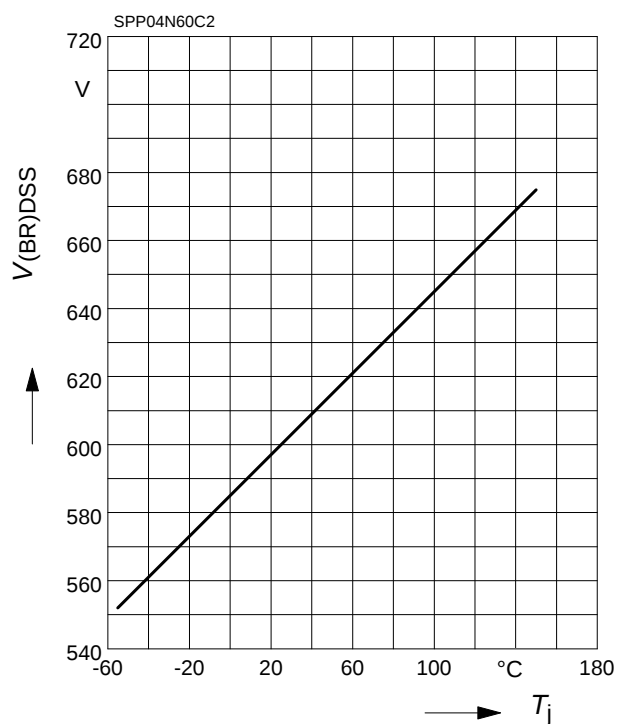
$E_{AS} = f(T_j)$

par.: $I_D = 3.6\text{A}$, $V_{DD} = 50\text{V}$



20 Drain-source breakdown voltage

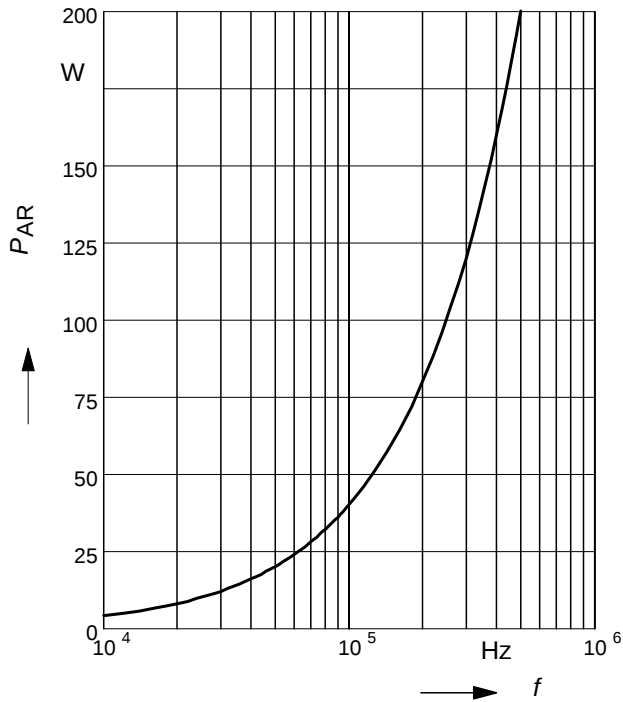
$V_{(BR)DSS} = f(T_j)$



21 Avalanche power losses

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

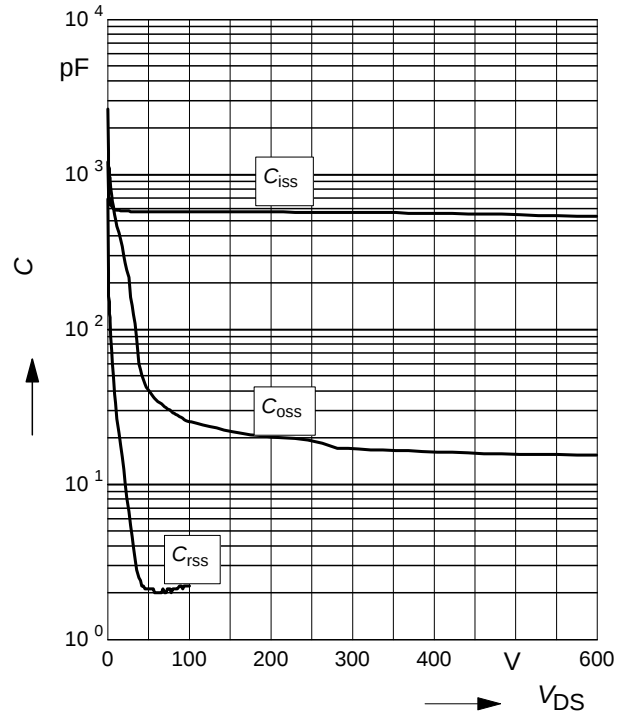
parameter: $E_{AR}=0.4\text{mJ}$



22 Typ. capacitances

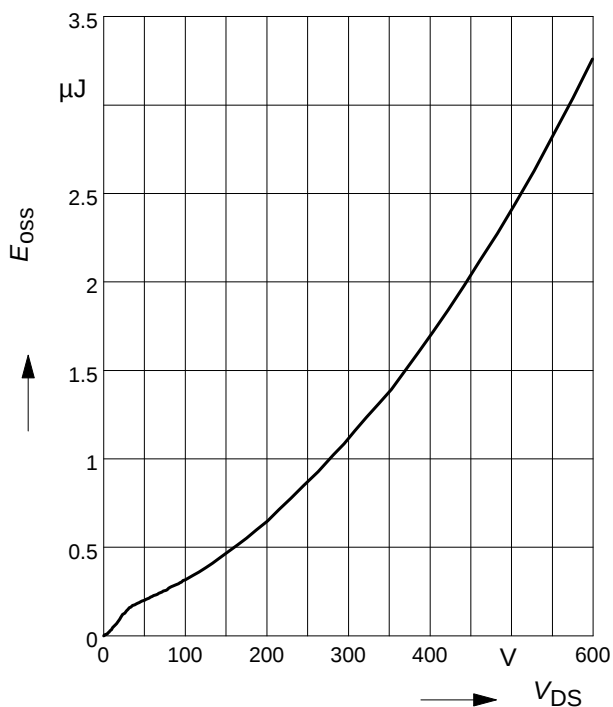
$$C = f(V_{DS})$$

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

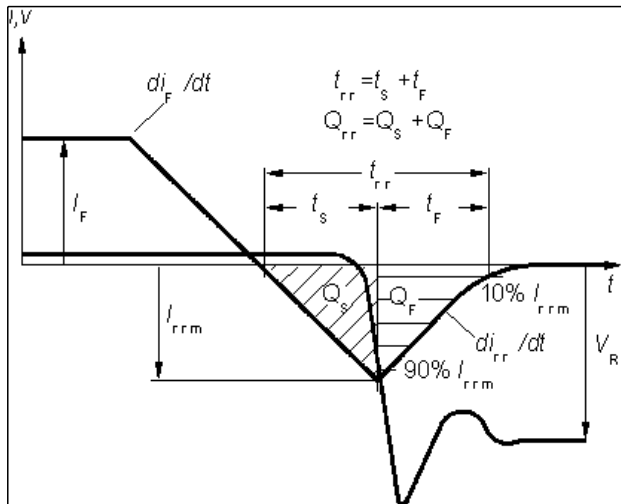


23 Typ. C_{oss} stored energy

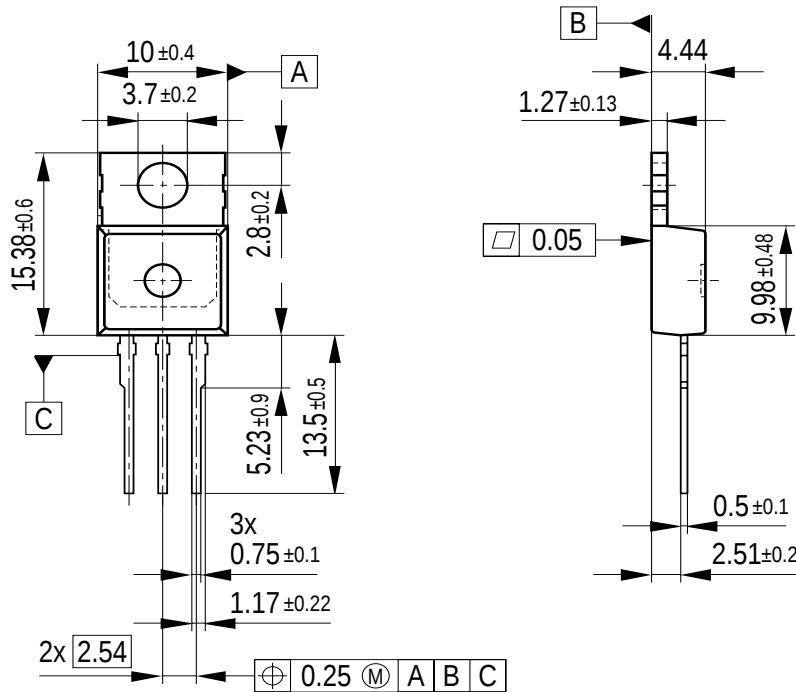
$$E_{oss}=f(V_{DS})$$



Definition of diodes switching characteristics

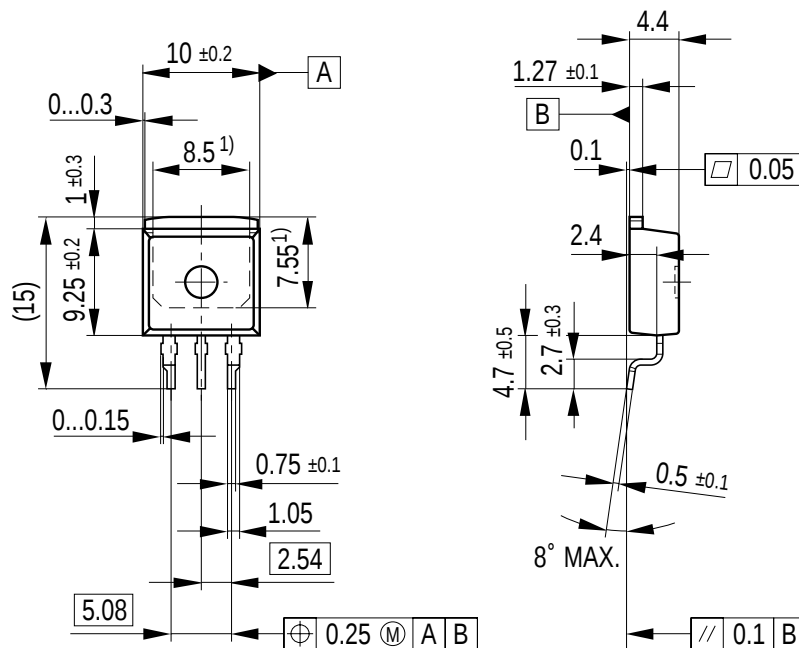


P-TO-220-3-1



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

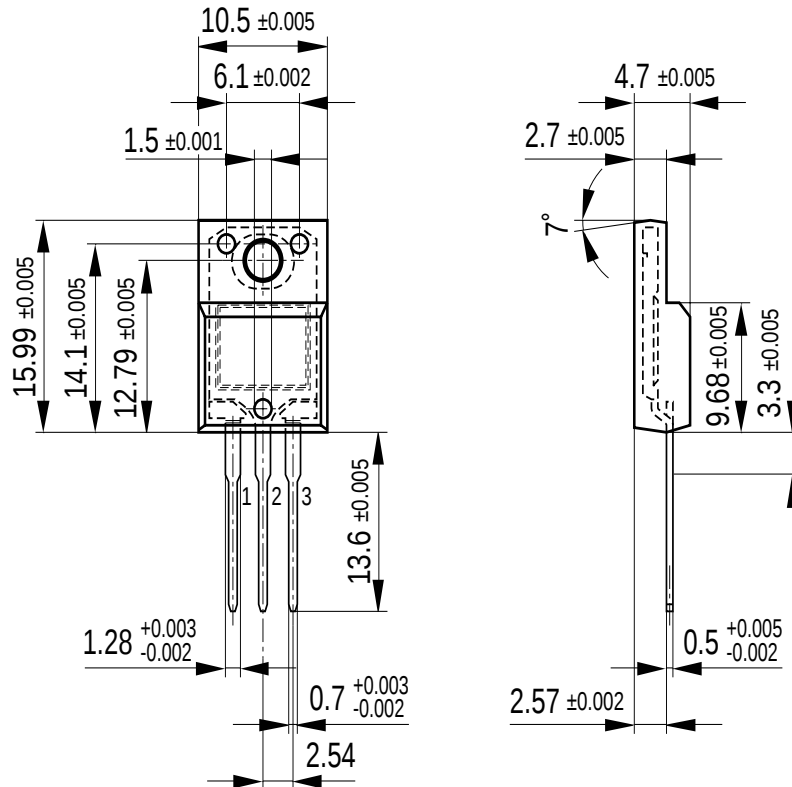
P-TO-263-3-1 (D²-PAK)



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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